

AGRICULTURE AND ANIMAL HUSBANDRY IN INDIA



Paddy cultivation in Kulu

**AGRICULTURE AND ANIMAL HUSBANDRY
IN INDIA**

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TO

P. N. THAPAR

Secretary, Ministry of Food & Agriculture
Government of India
(1954 - 1958)

In gratitude for the great encouragement he gave in the
production of literature on Agriculture

PREFACE

THE first edition of Agriculture and Animal Husbandry in India which was published in August, 1958, was exhausted in about a year's time. This is ample testimony to its usefulness. The second edition, which is being brought out in response to an insistent demand for it from different parts of the country, incorporates all the latest information on the subjects dealt with in the book.

When I joined the Indian Council of Agricultural Research as its Vice-President in October, 1955, I asked for a book which could give me information about the important crops of India, their production, improved varieties as well as breeds of farm animals. Though a book of this nature was not forthcoming, I found that there was sufficient material available in the Farm Bulletins, special issues of the Indian. Farming and the reports of the Indian Council of Agricultural Research and the Ministry of Food and Agriculture. On going through this material, I came to the conclusion that it could be compiled in the form of a useful reference book. It was thus that this work was started. Though the original intention was to deal with the crops and farm animals only, the scope of the book had to be extended. When we want to learn about the existing crop pattern and the distribution of domesticated animals in India, we have to look far back into the geological past of the country. Why the soils and crops of Peninsular India differ so radically from the crops and soils of the Indo-Gangetic plain in northern India? These are the questions which can only be adequately answered if we know facts about the geological history of the sub-continent of India. It is from the rocks that the soils are born. Climate and the cover of vegetation affect the soil. Hence, if we want to know facts about agriculture and animal husbandry of a country, we have also to take into account the geology, climate and vegetation. In fact, it was on the basis of these three important factors that the agricultural and animal husbandry regions of the country were drawn.

This book contains information on all the important food and commercial crops of India. Facts regarding production of different crops as well as their important improved varieties are given. Facts are also given about the breeds of cattle, sheep and

goats, and poultry. The various varieties of estuarine and marine fishes, which are of commercial importance, are also described.

A publication of this nature implies co-operation of a number of experts. The material on agriculture which is largely based on the material published in the various publications of the Indian Council of Agricultural Research has been carefully vetted by Dr. B. N. Uppal, former Agricultural Commissioner with the Government of India, Indian Council of Agricultural Research, and Dr. B. P. Pal, Director, Indian Agricultural Research Institute. Material on fruit crops has been supplied by Dr. Sham Singh, former Deputy Agricultural Commissioner (Fruit Development), Indian Council of Agricultural Research. Dr. S. Krishnamurti has supplied material on plantation crops of South India, particularly coriander, cloves, nutmeg, cinnamon and cinchona. The Secretaries of the Commodity Committees, particularly, Dr. B. L. Sethi, Secretary, Indian Central Cotton Committee, Dr. R. Sankaran, Secretary, Indian Central Oilseeds Committee, Dr. P. J. Gregory, Secretary, Indian Central Coconut Committee and Shri B. S. Varadarajan, Secretary, Indian Central Arecanut Committee, have supplied very useful maps showing the distribution and production of cotton, oilseeds, coconut and arecanut, as well as information about the improved varieties of these commodities. Dr. Pushkarnath, Director, Central Potato Research Institute, Simla, supplied maps on the distribution and production of potatoes in India.

The material on the geology of India is largely based on the Presidential Address of Dr. D. N. Wadia, Geological Adviser to the Government of India, Department of Atomic Energy, at the Indian Science Congress in the year 1942. The chapter relating to Gondwanaland is based on the papers published by Dr. D. N. Wadia, late Dr. Birbal Sahni and Dr. West. The chapter on soils is based on the information supplied by Dr. S. P. Raychaudhuri, Head of the Division of Chemistry, Indian Agricultural Research Institute. The chapter on climate, prepared from the material supplied by Dr. B. Ramdas, Deputy Director-General of Meteorology (retired), has been carefully revised by Dr. L. A. Ramdas, Head of the Division of Heat and Power, National Physical Laboratory, New Delhi. The chapter on vegetation is largely based on the classical essay of Dr. Hooker, my personal observations, and on an excellent summary of vegetation in the forests of India by Mr. M. D. Chaturvedi, retired

Inspector-General of Forests, Ministry of Food and Agriculture. The present Inspector-General of Forests, Mr. R. C. Soni, has revised the text with the assistance of Mr. S. K. Seth, Silviculturist, Forest Research Institute. It has been further improved by Dr. D. Chatterji of the Botanical Survey of India.

The material on agricultural regions, barley, millets, and maize has been revised by Dr. S. M. Sikka, Additional Agricultural Commissioner with the Government of India, Indian Council of Agricultural Research, New Delhi. Mr. Mahavir Prasad, Irrigation Adviser to the Government of India, Ministry of Food and Agriculture has provided the material for the chapter on irrigation. The chapter on agricultural holdings has been revised by Dr. G. D. Aggarwal, former Production Adviser, Directorate of Economics and Statistics, New Delhi; on rice by Dr. R. H. Richharia, Director, Central Rice Research Institute, Cuttack; on wheat by Dr. B. P. Pal, Director, Indian Agricultural Research Institute, New Delhi; on pulses by Dr. T. R. 1Vlehta, Director, Farm Advisory Unit, Directorate of Extension, Ministry of Food and Agriculture, New Delhi; on potato by Dr. Pushkarnath, Director, Central Potato Research Institute, Simla.

The chapter on tea has been carefully revised by Mr. H. Ferguson, Director, Tea Research Station, Tocklai, Assam; on coffee by Mr. M. P. Appu Menon, Secretary, Coffee Board, Bangalore; on rubber by Mr. N. Krishna Pillai, Secretary, Rubber Board, Kottayam, Kerala; on sugarcane by Dr. B. K. Mukerji, Director, Indian Institute of Sugarcane Research, Lucknow; on tobacco by Dr. G. S. Murty, Director, Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh; on Lac by Dr. Krishna-Swami, officiating Director, Indian Lac Research Institute, Ranchi, Bihar; on coconut by Dr. K. P. B. Menon, Director, Central Coconut Research Station, Kayangulam, Kerala; on arecanut by Mr. B. S. Varadarajan, Secretary, Indian Central Arecanut Committee, Kozhikode, Kerala; on cotton by Dr. B. L. Sethi, Secretary, Indian Central Cotton Committee, Bombay; on jute and mesta by Dr. B. C. Kundu, Director, Indian Central Jute Research Institute, Barrackpore, West Bengal; on groundnut, castor, niger, sesamum, linseed, rape and mustard by Dr. R. Sankaran, Secretary, Indian Central Oilseeds Committee, Hyderabad; on pepper, chillies, cardamom, ginger, turmeric, tapioca, cashewnut and other spices by Mr. K. Fazlullah Khan, Cashewnut and Spices Development Officer, Ernakulam, Kerala;

and on cinchona, betel and lemon-grass by Shri Y. M. L. Sharma, Dean, Indian Forest Research Institute.

The original material on cattle was provided by Dr. R. L. Kaura, Cattle Utilization Adviser, Ministry of Food and Agriculture. It has now been made up-to-date by Mr. M. R. Mahajan, Livestock Development Adviser, Ministry of Food and Agriculture. The chapters on-sheep and goat have been revised by Shri L. Sahai, Animal Husbandry Commissioner with the Government of India, Indian Council of Agricultural Research, with the assistance of Mr. S. S. Khot, Sheep and Wool Liaison Officer, Indian Council of Agricultural Research. Dr. D. R. Bhatia, Deputy Fisheries Development Adviser, Ministry of Food and Agriculture has revised the chapter on fishes.

The book has been illustrated with a number of maps, charts and photographs. The maps have been drawn by the Art Section of the Indian Council of Agricultural Research under the supervision of Shri N. S. Bisht, Director of Art, and are based on the material supplied by the Directorate of Economics and Statistics of the Ministry of Food and Agriculture, the Statistical Wing of the Indian Council of Agricultural Research, and the Commodity Committees. The photographs of crops and animals which serve as illustrations were taken by Shri H. K.

Gorkha, the talented photographer of the Indian Council of Agricultural Research, who accompanied the author on his tours in different States of India.

The statistical tables given in the Appendix have been compiled from various publications of the Directorate of Economics and Statistics, Ministry of Food and Agriculture. I am grateful to Dr. R. N. Poduval, Economics and Statistical Adviser and Dr. S. B. L. Nigam, Deputy Economics and Statistical Adviser, for the ungrudging co-operation they have given in supplying the statistical material. But for the help they have provided so magnanimously, it would not have been possible to collect such useful data.

The entire material for this edition has been edited and processed for the press by Mr. Krishan Kumar, and Mr. M. K. Jain, Assistant Editors under the guidance of Mr. D. Raghavan, Chief Editor and Production Specialist, Indian Council of Agricultural Research. Proofs have been read by Mr. J. B. Bali, Sub-editor. I would like to express my appreciation of the work

put in by Mr. E. Parthasarthy and Mr. Satya Paul in typing out many chapters of this book. The bibliography has been prepared by Dr. D. B. Krishna Rao, Librarian, Indian Council of Agricultural Research.

I have every hope that this book will prove useful to all people who are interested in Indian agriculture whether as administrators, agricultural officers, teachers or as students. It would also provide foundation material for a suitable book on Agricultural Economics of India: Considerable ignorance prevails regarding the crops which are grown in different parts of India, and I feel that this book would be of particular use to professors as well as students in Agricultural and Veterinary Colleges in the States.

New Delhi
April 4, 1961

M. S. RANDHAWA

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SECTION I

THE LAND

CHAPTER 1

THE GEOLOGICAL PAST

THE geology of a country provides the fundamentals of the natural history of its entire plant and animal life. For a proper appreciation of its geographical peculiarities in relation to the development of its vegetation, agriculture and animal life, we have to look back into the dim past of its geological history. The present study, therefore, begins with a survey of the geological heritage of India.

PHYSICAL DIVISIONS

The most outstanding fact about the physical geography and geology of India is the natural division of the country into three distinct segments of totally dissimilar characters: (i) the great, flat alluvial plains of northern India extending from the Punjab to Assam-the India of legend and history; (ii) the Peninsula of the Deccan, sprawling to the south of the Vindhyan mountains-a solid and stable block of the earth's crust, largely composed of some of the most ancient rocks, which the denudation of ages has carved out into a number of mountain ranges, plateaus, valleys and plains; and (iii) the great mountain barrier which surrounds the plains in the west, north and east.

The plains of northern India, or the Indo-Gangetic plains, though of the highest importance from the point of view of culture and civilization, inasmuch as they have been the principal theatre of India's history and a source of the great agricultural wealth of the country, are geologically speaking the least interesting part of India. In geological history, they supply annals of but yesterday, being composed of very late, sub-recent alluvial and flood-plain deposits of the rivers of the Indus-Ganges system, borne down from the Himalayas. The plains have covered up, under their deep mantle of clays, sand and silt, valuable geological records which might have thrown light on the physical history and relations of the Deccan with the Himalayas. These plains were originally a deep depression or furrow, which came into existence as a complement of the process of elevation

of the Himalayan chain to their north. The filling up of this depression is the work of the later part of the last geological age-the Pleistocene.

The following differences summarize the main points of divergence between the peninsula of the Deccan and the Extra-Peninsula.

The first difference is stratigraphic, or that connected with the geological history of the areas. Ever since the Cambrian period, the dawn of geological history, the peninsula has been a land area, a continental segment of the earth's circumference, which, since that epoch, has never been submerged under the sea except locally and temporarily. No appreciable marine deposits of an age later than the Cambrian, have been laid down in the interior of this land-mass. The Extra-Peninsula, on the other hand; has been a region which has been underneath the sea for the greater part of its history, and has, therefore, been covered by successive marine deposits characteristic of all the geological periods commencing from the earliest, the Cambrian.

The second difference pertains to the geological structure of the two regions. The peninsula reveals quite a different type of structure of the earth's crust from that shown by the Extra-Peninsula. Peninsular India is a segment of the earth's outer shell which is composed, in great part, of generally horizontally reposing rock beds that lie firm and immovable upon a stable and resistant foundation and that have remained so for a long cycle of ages, impassive and unfolded amid all the revolutions that have again and again altered the face of the earth. The only structural disturbance it has undergone is of the nature of lines of faults or fractures in the crust, due to tension or compression. The Extra-Peninsula, on the contrary, appears to have been a weak and comparatively flexible portion of the earth's circumference that has undergone a great deal of crumpling and folding of the rock beds indicating repeated upheavals and subsidence under the sea.

The third difference between the Deccan and the highlands of northern India is physiographical, and arises from the two above-mentioned differences. In the peninsula, the mountains are mostly of the 'relict' type, i.e., they are not true mountains of upheaval, but are mere outstanding portions of the old plateau of the peninsula that have escaped, for one reason

or the other, the weathering of ages which has removed the surrounding parts of the land. Its rivers have flat, shallow valleys, with low gradients, because of their channels having approached to the base level of erosion. Contrasted with these, the mountains of the other areas are all true mountains, owing their origin to a distinct axial uplift of the rock beds. The rivers of this area, as a consequence, are torrential streams, . which are still in a young or immature stage of river development and are continuously levelling the inequalities in their courses and degrading or lowering their channels.

SYSTEMS OF ROCK FORMATION

Archaean System. The Archaean is the name given to the oldest rock system of the world, forming the very basement on which all the succeeding systems of the geological column rest. This system is believed by some to represent the first solidified crust of the earth as it, cooled from its original molten condition. These rocks are as old as life itself. They are largely a mixture of gneisses, granites and schists, all thoroughly crystalline and permeated by ingestion of magma from the deeper plutonic parts of the crust (orthogneisses and orthoschists). With these crystalline plutonic rocks are associated elastic sediments, which have undergone an extreme degree of metamorphism, due to heat and pressure of earth's interior, and have been converted into foliated crystalline rocks (paragneisses and paraschists). Owing to the conditions under which these rocks were formed and their subjection to mechanical deformations that have taken place in the surface layers of the earth, through the whole vista of geological time, the Archaean rocks have attained an extreme complexity of character and relations in all parts of the world, which have not yet been completely unravelled. The Archaean rocks cover three-quarters of a -million square miles of the surface of Peninsular India, particularly in the regions of Madras, Mysore, Orissa, the former Central Provinces, Chhota Nagpur, and Rajasthan. They extend north-westwards along the chain of the Aravalli mountains, one of the oldest mountain ranges in the world, while they build, together with the intrusive granites of later ages, the central snow-covered ranges of the Himalayas

throughout their whole length, forming the very backbone of the mountains. All the high peaks of the Himalayas, from the Nanga Parbat in Kashmir to Mt. Everest in Nepal are, however, largely composed of granite, which has pierced through the , basement complex and is of a much later age.

Dharwar System. The system of rocks named Dharwarian is closely associated with the Archaean gneisses and is probably of the same age. These rocks are, however, chiefly of sedimentary origin, deposited in the hollows and depressions of the primeval crust, in which the first-formed seas of the world collected their waters on the condensation of the primeval vapours. The component rocks are mainly slates, hornblende and chlorite-schists, quartzites, crystalline limestones, and calcgranulites, charged with abundant and widespread granite intrusions. The Dharwarian system is best developed in Dharwar (the type-area), parts of Mysore State, Rajasthan (where it forms the outskirts of the Aravalli chain), parts of the former Central Provinces and Chhota Nagpur, and in the belt of metamorphic sediments in the middle Himalayas. The Dharwar rocks of these different regions illustrate varying characters: In the Dharwar district of the former Bombay State, from which the system takes its name, and in Mysore State they occur in long narrow bands with bottoms of compressed synclinals, the intervening anticlinal folds having worn away. The constituent rocks are hornblende and other schists, slates, quartzites and brilliantly banded cherts. Numerous quartz veins or reefs traverse these rocks, some of which are auriferous with a gold content enough to support mining operations. The principal gold mining centre in India, the Kolar fields of Mysore, is situated on these quartz reefs.

The Aravalli system of Rajasthan, consisting of variously metamorphosed limestones, phyllites, slates, quartzites and composite gneisses is one vast formation flanking the synclinorium stretching from Delhi to north Gujarat, whose uplift at the end of the Purana Era gave rise to the most ancient mountain-chain of India. Overlying the Aravallis unconformably, there comes another Archaean rock formation, the Raialo series, chiefly of marbles.

The Archaeans of Bihar and Orissa carry what is known as the iron ore series, from its containing iron ore strains of large dimensions. These rocks are shales, slates and tuffs, and

banded haematite quartzites containing massive or powdery haematite. The petrogenesis of the latter rocks is a subject of some controversy. Considerable igneous action prevails, which has given rise to the chromite, asbestos and steatite of Singhbhum. A copper-bearing belt runs along a plane of overthrust in the schists and intrusive granite of Singhbhum. The iron ore series is underlaid by a group of crystalline limestones, schists and manganese ore beds-the Gangpur series.

The Archaean-Dharwar complex of the former Centraik Provinces is also characterized by a metalliferous series of deposits rich in ores of manganese. The country rocks of the districts of Nagpur, Chhindwara and Bhandara are distinguished as belonging to the Sausar series, which consists of granulites, calciphyres, sillimanite-schists, and hornblende-schists carrying important aggregates of manganese ores. The Sakoli series of the southern districts, consisting of less altered slates, chlorite-schists and jaspilites, is probably an upward extension of the Sausars. The famous marble rocks of Jabulpore as well as the richly manganese deposits of rocks, named by Sir L. L. Fermor the 'Gondite Series' and the 'Kodurite Series', also belong to this system.

Eparchaean Interval. The rock-formations grouped under the Purana Group roughly correspond in age to the Algonkian System of the American geologists. These succeed the Archaean after a profound regional unconformity. This unconformity is of great significance as it denotes the lapse of a vast interval of time, represented by many cycles of mountain-building and their erosion to the base level before the lowest beds of the Puranas were deposited. The Purana rocks are of a great thickness of preCambrian unfossiliferous slates, quartzites, sandstones and limestones, found principally in the Aravalli chain, the Cuddapah area of Madras, and in the great escarpment of the Vindhyan mountains in central India. The Cuddapahs and the Delhis are older and show a greater amount of tectonic plication and deformation than the Vindhyan, which are hardly disturbed from their original horizontal attitudes.

Cuddapah System. The type-area of the Cuddapahs is the district of this name in Andhra Pradesh where the system consists of 20,000 feet of indurated shales, slates, quartzites and limestones, with bedded lava-flows and tuffs. As in the Dharwar, there occur also brilliantly banded ferruginous jaspers

and some manganese ore. The whole group, though admirably adapted to contain and preserve organic relics, is totally barren of fossils. Workable deposits of barytes and asbestos occur in association with the Papaghni slates and limestones, the lowest member of the Cuddapahs of the Ceded Districts of Madras.

Vindhyan System. The next succeeding system, the Vindhyan, is in most of its area of extension an undisturbed formation, with generally horizontal stratification-planes, resting over the upturned and denuded edges of the underlying rocks. The Vindhyan sediments, 14,000 feet in thickness, show two distinct fades of deposits—a lower argillaceous and calcareous (the Semri series of the Sone Valley area) and an upper, almost exclusively arenaceous, divided into three series, the Kaimur, the Rewa and the Bhander of central India. The lower Vindhyan show a certain amount of structural displacement and folding, and are separated from the upper by an unconformity that is quite apparent in the north but disappears in the southern area of Mewar and the Sone Valley. Homotaxial in position with the lower Vindhyan is the Malani series of volcanic rocks, covering large areas of west Rajasthan. This series consists of partly glassy and denitrified, felsitic or amygdaloidal, rhyolites and quartz-andesites, interstratified with tuffs and volcanic breccias. The Malani series extends far northwards, and is observed in some isolated hillocks in the Punjab alluvium. The characteristic Malani rhyolite is distinguished in the boulders occurring in the Upper Carboniferous glacial moraines at the base of the Productus Limestone of the Salt Range, a fact which indicates that the Aravalli mountains were the feeding ground of the glaciers that radiated out to distant parts of India during the Upper Palaeozoic Ice Age. Connected with the Malani lava-flows, as their plutonic roots or magma reservoirs, are the bosses of granite of Jalor and Siwana.

Gondwana System. The Gondwana system representing widely distributed land deposits in the peninsula carries the geological history almost up to the time of the emergence of the Himalayas and the formation of the Indo-Gangetic alluvium plain. In view of its special significance to Indian geological history, it has been dealt with in a separate chapter. The birth of the Himalayas has, likewise, been treated separately.

CHAPTER 2

GONDWANA SYSTEM OF THE PENINSULA

Two facies of deposits in India, belonging to the Palaeozoic and Mesozoic eras, remain to be considered: a marine facies in the Extra-Peninsula; and a freshwater and terrestrial facies in the peninsula. The latter system of land deposits is known in Indian geology as the Gondwana system after the typical basins of these rocks occurring in the Gond country to the south of the Narmada. It is of wide distribution in the Damodar, Mahanadi and Godavari valleys, and in the Satpuras, and is also met with in smaller patches in a number of far distant outliers in Kashmir, Sikkim and Abor Hills. The dense forest vegetation which covered Central India in ancient times has given rise to massive seams of coal, 20 to 80 feet thick, in the lower part of the Gondwanas, which constitute one of the most productive geological horizons in India, supplying 46 million tons of coal annually. Some iron ore is also associated with the coal seams.

The Gondwana system is divided into two parts—Lower and Upper. A thick zone of intervening strata, exhibiting intermediate characters, is sometimes separated as the Middle Gondwana division. The lower Gondwanas range in age from the Permo-Carboniferous to the Trias. At their base is a glacial boulder-bed occurring at widespread centres from Orissa to the Salt Range and Hazara—containing ice scratched pebbles, which testify to the prevalence of glacial ice covering the land surface of India as far south as Lat. 20°. This is overlain by a thick series of coal measures—the Damodar series. This series, at places 10,000 feet thick, carry the most important coal deposits of India. The Gondwana system has been a subject of much scientific speculation. It is necessary, therefore, to discuss in some detail the available mass of information.

GONDWANALAND—THE GREAT SOUTHERN CONTINENT

Gondwanaland is the name given to the great southern Indo-African American continent which stretched across the world to the south of the Tethys Sea. Medlicott, Blanford and

Feistmantel are the founders of the Gondwana System. It was carefully scrutinized by R. D. Oldham in 1893; and has since been adopted by the Geological Survey of India.

The rocks of the Gondwana system cover a period of over 150 million years. Though scores of geologists in India, Australia, South America and South Africa have been unravelling the geographic details of Gondwanaland, the main credit for the discovery of this dim and frozen continental region goes to Blanford Brothers. According to Wegener, Gondwanaland was a compact mass, which was subsequently broken into blocks which drifted apart, and are now known as a Peninsular India, Madagascar, South Africa, South America, Australia and Antarctica. To the north of the Tethys Sea was the continent of Angaraland.

According to Wegener, the continents are not fixed entities of the earth's crust, but have floated over a viscous floor, farther and farther apart. Suess, the well-known Austrian geologist, described the earth's crust as consisting of two zones: the upper zone, which he called the Sial, consisting of acidic rocks, such as gneiss and granite, containing 60-'75 per cent of silica and sedimentary rocks of all ages, which formed the upper and lighter shell; and the lower zone, which he called the Sima, composed of heavier basic rocks, such as basalt, with a lower silica content. Wegener visualizes the continents as a rocky scum of Sial floating on the denser Sima which, beyond the submerged edges of the continents, forms the floor of the ocean. The basaltic Sima probably rests on heavier material, iron or an iron-nickle alloy. According to this view, the earth is believed to be solid throughout. Wegener assumed that Sial was more or less equally spread over the whole surface of the earth, and formed the floor of a universal ocean with an average depth of about 3,000 metres, which he named Panthallasa. Later on, the granite crust was crumpled up into a world continent, occupying about half of the earth's surface, which he called Pangaea. The world continent of Pangaea was disrupted into three land masses, a giant continent in the south, and two continents in the north separated from each other by the Tethys Sea. These three blocks were further disrupted into smaller blocks which drifted away due to the earth's movements. According to this view, the sundering oceans are a measure of the distance to which the disrupted pieces of the former giant continents have floated

farther and farther apart over a viscous floor. Wegener regards the Atlantic as a great rift in the Sial, which has gradually broadened in the course of ages. The other view held is that the present continents are fixed portions of the earth's crust, and are remnants of much bigger continents which foundered causing large areas to sink. It is possible that vast land areas may have been lost, but available geological, palaeontological and other evidences point in the other direction, and lend support to the views of Wegener.

Rocks in the Peninsular India, which range in age from the Upper Carboniferous to the Jurassic that form a connected sequence, are a prominent feature of the geology of South India. These rocks were first known from the ancient Gond Kingdom, south of the Narbada, and were hence named as Gondwana system by Suess. Similar organic and physical features are seen in rock systems of South Africa, Madagascar, Australia, and South America. There are unmistakable affinities between the freshwater fishes and other lower vertebrate fauna of India, Madagascar and South Africa. The Cretaceous dinosaurs of the erstwhile Central Provinces of India have close resemblance in many respects, to those of Madagascar, Patagonia, Brazil and Uruguay. Perhaps the most interesting of the earlier discoveries were those of South America, of which W. T. Blanford wrote: ". now these discoveries one after another of the exceptional character that have made the Indian, Australian and South African beds famous in the history of geological science, have been completed by the recognition in the South America of that remarkable and characteristic flora which first drew attention to the whole question. It is curious how the typical forms of the Lower and the Upper Gondwanas have been gradually traced in India, Australia and South Africa, how in each case a peculiar boulder-bed has been found associated with them, and how every one of the same peculiar features has now been met with in South America. Not the least remarkable fact, moreover, is the peculiarly Indian faunas of the Argentine. flora the association of *Neuropteridium aalidum*, *Feistm.*, *Ganga.* *mopteris cyclopteroides*, *Feistm.*, and *Noeggerathiopsis hislopi*, *Feistm.*, being characteristic of the Karharbar i beds "

Hettner described the coal-measures of southern Brazil, and stated that he had obtained from them fossil plants belonging to the Glossopteri; flora. Prof. R. Zeiller examined the

specimens noticed by Dr. Hettnei as pertaining to the *Glossopteris* flora, and has ascertained that they comprise *Gaiagamopteris cyclopteroides* associated with *Lepidophloios laricinus* and a *Lepidodendron*.

Kurtz had found a *Lepidodendron* associated with the *Glossopteris* flora in Argentina. The same appears to be the case in southern Brazil.

Apart from these evidences, the physical configuration of the land which formed the Gondwanaland, also lends weighty support to Wegener's hypothesis. Peninsular India, Madagascar, South Africa and South America fit into each other like pieces of a jigsaw puzzle.

Due to crustal movements, which gave birth to the Appalachian Mountains in the eastern North America, and other earth movement which took place in the Carboniferous Period, large blocks of the country subsided in Peninsular India and other parts of Gondwanaland. In these troughs, the rivers of the Gondwana country poured their detritus including debris of forest vegetation. These loaded troughs here well preserves among the Archaean crystalline rocks; and it is from the coal seams enclosed in the Gondwana rocks that almost all the coal of India is derived. In these troughs not only coal was preserved and made, but also saved from crushing and folding which would have destroyed their commercial value, by making the extraction of the coal difficult and costly. The Gondwanian deposits were river deposits, as is proved from the nature of the detritus presence of terrestrial plants, crustaceans, insects, fishes, amphibians and reptiles, as well as from the total absence of marine animals like corals crinoids, etc.

GONDWANA ICE AGE -

Several climatic changes took place in the Carboniferous Period. From the presence of boulder-beds, a glacial epoch in the Upper Carboniferous of Gondwanaland is well established. These boulder-beds occur not only in Peninsular India, but also in Australia and South Africa. The lowest beds of the Lower Gondwana are known as Talchir series, after Talchir district of Orissa. Talchir series is divided into two stages, of which the lower is recorded from the Rajmahal Hills to the Godavari and

from Raniganj to Nagpur, and consists of green laminated shales and soft fine sandstones. The presence of undeveloped felspar grains in the sandstones suggests the prevalence of land-ice and the disruptive action of frost. Glacial sandstones are also indicated by the presence of glaciated and striated blocks of rock, up to 30 tons in weight embedded in a matrix of fine silt. This indicates' that the boulders and rocks were transported in floating blocks of ice, and were dropped in Talchir troughs. According to Wadia, the Aravallis were the chief gathering grounds for the snow fields, and from these the glaciers radiated in all directions. The first discovery of the evidence of the Upper Palaeozoic glaciation by Blanford Brothers was received with scepticism as the nebular hypothesis which held sway presupposed a cooling earth. As Dr. Cyril Fox observes: " When the Blanford Brothers put forward the suggestion of the presence of ground ice in India at the ancient epoch, marry of their colleagues refused to accept the idea as even probable. It must be remembered that 75 years ago it was firmly believed that the earth was a cooled mass which was thought to have begun as a nebula. It was accepted that as a cooling body there could, at no previous age, have been a cold climate. The coal-measures of the Carboniferous Period of Europe provided evidence in favour of former tropical conditions. Physicists calculated the age of the earth on the basis of a cooling body, still hot within but steadily losing heat. How then, it was argued, could there have been extensive glaciation in a remote epoch of geological time."

" The scientific world at large had accepted the idea that the termination of all life on this earth was fore-doomed. It became a question of calculation as to how many thousands=or millions of years would be necessary for the climate to become so cold as to be inhospitable to life. There seemed no prospect of escape from the gradual loss of heat and eventual freezing of the surface of the earth. Then came the challenge to these old ideas by the Blandfords. It is not, I think, fully understood what their considered opinions, followed by unmistakable evidence not only from India, but from South Africa, Australia and South America, have meant. It has necessitated the abandonment or at least an emendation of the nebular hypothesis; it made the discovery of radio-activity a foregone conclusion; it has shown that the earth is immeasurably old and relatively unchanging except in the evolution of life; it has removed all fear in regard to

the end of the world by loss of internal heat; it has cleared the way for modern opinions in regard to past climates; and it has placed us at the threshold of our enquiries into the structure of the earth and the beginnings of life on this planet. Our studies of the Gondwana system and of related formations in India and other countries have thus a definite geological horizon of great value. We know that a period of extensive glaciation had overwhelmed a large part of the southern hemisphere towards the close of the Palaeozoic Era."

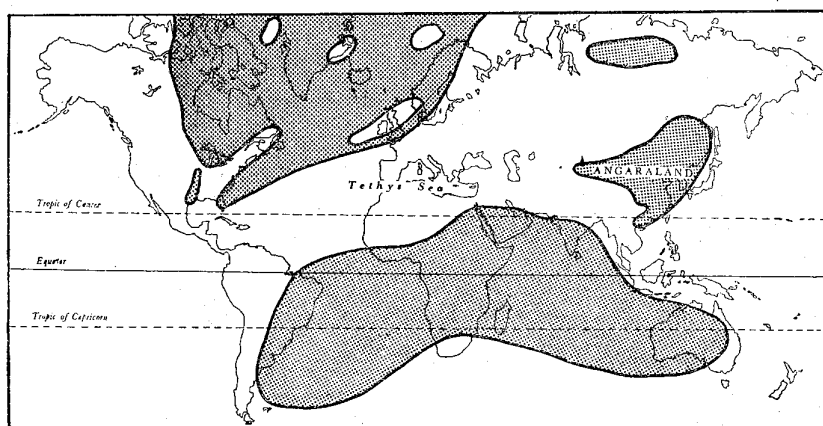


FIG. 1. The continents at the close of the Carboniferous Period

However, in the succeeding strata we find thick local seams, which indicate a luxuriant vegetation and a warmer climate. This is followed by another cold cycle in the Panchet series. The Panchet epoch is succeeded by the Middle Gondwana thick red sandstones indicating arid desert conditions. The comparatively cold climate of Gondwanaland is partly accounted for by the presence of a cold sea with floating icebergs to the south, protruding like a wedge between the Gondwanaland and the Antarctic Continent.

LIFE IN CARBONIFEROUS PERIOD-THE COAL AGE, THE AGE OF AMPHIBIA AND LYCOPODS

The correspondence of the Gondwana system with the geological periods is shown in the chart below. The

nomenclature employed for the time and stratigraphical units of the divisions is based on accepted geological terminology, i.e., eras of time represented by groups of strata; periods of time represented by systems of strata; epochs of time represented by series of strata; ages of time represented by stages of strata; and phases of time represented by beds, horizons or zones of strata.

GONDWANA SYSTEM OF THE PENINSULA

THE GONDWANA SYSTEM

	Epochs	Phases	Periods	Eras
		Umia stage -		
	Jabalpore Series	Jabalpore stage	Cretaceous	
		Chaugan stage		
Upper Gondwana		K0ta stage		
	Rajmahal Series	Rajmahal stage I	Jurassic	
		Parsora stage		Mesozoic
		Maleri (Dedwa) stage		
	Mahadeva Series	Pachmarhi stage I		
Middle 'Gondwana			Triassic	
	Panchet Series	Hirapur stage		
		Maitur stage (Mangli beds)		
	DAMUDA Series	SERIES		
	Raniganj Series	stage		
		Kamthi		
		Raniganj or upper		

		coal- measures		
	Barren Measures	Mahuda stage		
		IronstoneshaleorK ulti stage	Permian	Palaeozoic
Lower Gondwana		Barakar or lower coal- measures		
	Barakar Series j	Karharbari stage		
		I Umaria marine beds		
		Rikba plant stage	Upper Car-	
	I Talchir Series	Talchir needle- shales	boniferous	
		Glacial boulder- bed		

TETHYS OCEAN

Is there any evidence about the existence of the Tethys Ocean? Yes, there is plenty of evidence about the existence of this lost ocean in India. The mountain chains of the Himalayas, which lie to the south-west of the Tibetan frontier are marine formations, alternations of limestone, and fossiliferous clays. At altitudes ranging from 16,000 to 20,000 feet are found fossils of marine animals like corals, sea-lilies and ammonites. Black stones with impressions of marine-shelled animals like ammonites, commonly known as shaligrams, are brought from the Himalayas by sadhus for sale in the bazaars of Hardwar. The limestone from this area is composed of millions of shells of minute sea animals known as Radiolaria, which must have swarmed the ancient Asiatic Mediterranean, the Tethys. Even now millions of Radiolaria swarm our oceans, and the shells of these animals pour down into the depths of the ocean, forming the sea-ooze. Fossils of ammonites are found in rocks extending

from Cutch to Jaisalmer in Rajasthan, which suggests that the Gujarat coast of Gondwanaland was washed by a small bay of the Tethys Sea, which extended along the Equator from the present Mediterranean, which is one of its remnants, to the heart of China.

Throughout the long ages, from the Permian about 200 million years ago till the close of the Eocene about 70 million years ago, the bed of the ocean was settling down under the weight of the accumulating sediments over 50,000 feet in thickness. Another evidence of the existence of the Tethys in the Tertiary, lies in the inland lakes and seas of the Asiatic Continent like the Aral, the Caspian, the Black Sea and the Mediterranean, which are really the shrinking remnants of the Tethys.

DISRUPTION OF GONDWANALAND

Peninsular India, Australia, Madagascar, Africa and South America were huddled together as a compact continent in the Mesozoic period. If outline maps of these countries are cut, we find that they fit in like the pieces of a jigsaw puzzle. The eastern edge of South America fits into the western border of Africa, and Madagascar fits into the eastern coastline of South Africa. Wegener compares the continents to drifting icebergs detached from a continuous floating mass of ice. Wegener's theory finds support not only in the physical configuration of the daughter continents, but also in their geological similarity. According to him, the original land mass of Gondwanaland disrupted and the dismembered blocks floated into their present positions. Evidence of this disruption of Gondwanaland also lies in the straight and steep contours of the Malabar coast. This dismemberment was not a sudden event but was probably a long process. The first part to separate was Australia and the Malay Archipelago. Later on South America drifted away from South Africa. Lastly, the land-bridge between India and Madagascar, known as Lemuria, foundered, and thus the Arabian Sea came into existence. These earth-shaking events took place at the beginning of the Eocene period. While on one side we see the disruption of Gondwanaland into fragments, large segments of which drifted away and some got submerged in the sea, on the other hand we notice the uplift of the

overloaded bed of the Tethys into the lofty chain of the Himalayas.

Coeval with those earth movements was the volcanic eruptions of the great body of Deccan Trap lavas. It may be noted that the completion of the, gigantic volcanic discharge of the Deccan Trap coincided with the first uplift of the Himalayas.

At the end of the Cretaceous, and according to recent discoveries, at the commencement of the Eocene, the Deccan experienced a period of intense volcanic activity of a type that has no parallel among the volcanic phenomena of the modern world. Several hundred thousand square miles of the country were flooded by outpourings of basaltic lava from fissures in the earth's surface which was eventually converted into a plateau several thousand feet high (Deccan Trap). It is estimated that 4,00,000 cubic miles of molten rock which exceeds in bulk and volume the entire Himalayas, was poured out from the bowels of the earth.

The denudation of ages has carved out the plateau into numerous isolated, flat-topped and square-sided hill-masses, which are a characteristic feature of the landscape of the Western Ghats today. In the dissected sides of these peculiar ghat-shaped hills we see piles of bedded basalts, in 20 to 80 feet thick horizontal flows, separated by thin partings of sediments (inter-trappean beds). The inter-trappean beds are fossiliferous and, therefore, throw light on the history of the periods of quiescence which intervened between the volcanic outburst and the recurring migrations of animals and plants that took place. Numerous palms and some flowering plants, together with fishes, frogs, and various orders of reptiles flourished at this period in the Deccan, the petrified remains of which, from this and adjoining areas, bear witness to the advanced, more evolved forms of life that superseded the land life of the Gondwana period.

CHAPTER 3

BIRTH OF THE HIMALAYAS

WE have traced in the preceding chapter, the vicissitudes through which the Gondwanaland passed, and which culminated in its disruption. The volcanic upheavals which brought into existence the plateau of the Deccan, disturbed the balance of the earth, and according to the geologists, this led to the sinking of the Indo-Gangetic plain to a depth of many thousand feet in front of the Himalayas that were elevated as a result of the earth movements.

The Himalayas were born as a result of a gigantic compression between two continents, the northern Angaraland and the southern Gondwanaland. Due to the drift of these two continents, the loaded ocean floor of the Tethys began to upheave. The slow but irresistible movement of the two land blocks uplifted the sediments; and folded them into numerous mountain chains. The Angaraland got the better of the thrust as it occupied a higher position, and the mobile mountain masses flowed over the sinking lowlands of Gondwana. Round the resistant angular promontories of Gondwanaland the pile of sediments, folded somewhat like a Japanese fan, became bent sharply to the south-west into Hazara, and to the south into Burma. Slowly and gradually the erosive action of the sun, rain and snow sharpened the tops of these ranges into peaks.

These mountain-building movements continued off and on, throughout the Tertiary era, and far into the Pleistocene period when the greater part of northern India came under arctic conditions during at least three epochs separated by warmer inter-glacial intervals. The first upheaval took place towards the end of the Eocene; and the central axis of ancient sedimentary and crystalline rocks was ridged up. This was followed by a second upheaval about the middle of the Miocene. The third upheaval elevated the central part of the range as well as the fluvial deposits of the Siwalik river into the Siwalik mountains. The last upheaval began at the end of the Pliocene, and continued till after the middle of the Pleistocene.

The earth movements which gave birth to the Himalayas are still continuing, and stability has not been reached in this zone, as is evident from violent earthquakes like those witnessed in Assam, Bihar, Nepal, Kangra and Kashmir. Geologists believe that the Himalayas are still rising. The upthrust is, however, countered by erosion, which slowly grinds the mountains down. If there were no upthrust to offset the forces of erosion, the Himalayas would have been turned into a vast plain in course of time.

Even on striking a balance between the forces of upthrust and erosion, the Himalayas are slowly rising. On various grounds, Godwin Austin based the opinion that " within a comparatively modern period, closely trenching upon the time when man made his appearance upon the face of the earth, the Himalayas had been thrust up by an increment approaching 8,000 to 10,000 feet. " Evidence has been found in the form of chipped limestone implements in Kashmir, on both sides of Zojila Pass, which shows that the primitive man crossed this Pass without much difficulty which is so high now. In those times intercourse between Tibet and India was comparatively easy. The passes leading into Tibet have become more difficult owing to a rise of 3,000 feet or more in the height of the mountains.

How are the plains of northern India affected by these earth movements? Hiem is of the opinion that while the Himalayas are rising, the Indian alluvial plain is sinking by fits and starts, to the accompaniment of catastrophic earthquakes like the one that took place in Bihar. He is of the opinion that a similar compensative counter-movement was taking place to balance the upthrust of the Chinese and East Tibetan mountains, and that this partly accounted for the floods that frequently devastate the plains of Central China.

What have been the consequences of the rise of the Himalayas? Imagine India without the Himalayas! It would have been a bleak country indeed with no big rivers and a poor rainfall. Rainfall and snowfall have increased in the Himalayas due to their rise, and associated with this has been steady lowering of temperature and formation of glaciers. In the Quaternary Ice Age, the glaciers which are above 12,000 feet had descended to 6,000 feet. Outermost moraine are found at an altitude of 6,550 feet in the Alakananda Valley in Garhwal and below 6,000 feet on the south flank of the Pir Panjal in Kashmir.

While land on the southern side of the rising Himalayan barrier benefited from this upsurge, the land to the north was adversely affected. It is known from botanical and zoological evidence that Tibet was a comparatively fertile land, which later on became an alpine desert due to the rise of the Himalayas. Professor Grabau has advanced the hypothesis that Tibet was the cradle of mankind. During the Pliocene when an Ice Age came, primitive man found it impossible to return to the congenial climate of the plains of India. Stranded in Tibet, and compelled, to exercise his wits, he discovered the use of fire and clothing, two very great advances in civilization.

HIMALAYAN RIVERS

Many of the Himalayan rivers are older than the mountains they traverse, and had formed their channels in the early period of the Himalayan uplift. Some of the Himalayan transverse gorges or khads are thousands of feet deep. While the mountains were rising, the rivers stuck to their channels, which became deeper and deeper due to greater erosive action of the river water and the uplift of the mountains. While in the mountains the rivers stuck to their channels, scouring them deeper and deeper, in the plains they behaved differently and often changed their courses.

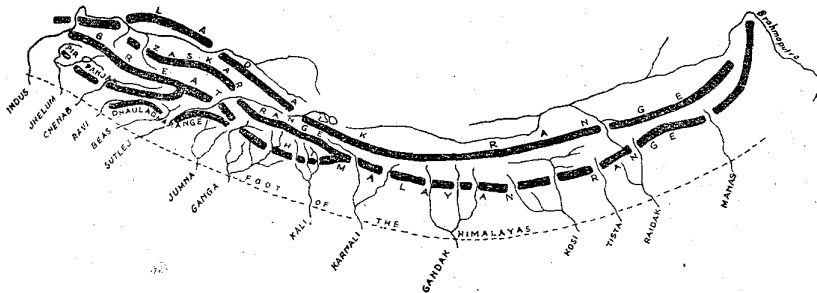


FIG. 2. Himalayan rivers

Tine Siwalik River. The Siwalik mountains are composed of river deposits, layers of clay, pepper-like sand with

boulders some of which may be as big as four feet in diameter, and rounded pebbles varying from the size of an orange to a man's head. According to Pilgrim and Pascoe these deposits were laid by a great old river variously called the ' Siwalik River ' and the Indo-Brahm, which received the combined discharge of the Brahmaputra, the Ganges and the Indus, and emptied itself in the gradually receding Miocene Sea of Sind and the Punjab, the remnants of the Tethys. Wadia supports the view of Pilgrim and Pascoe about the existence of the Siwalik river, and vividly describes how in the last glacial epoch, the elevatory movements of earth which raised up the Potwar Plateau in the Punjab, ultimately reversed the flow of this river. The drainage of the part of the Himalayas to the west of Simla flowed into the channels of the Chenab, the Ravi, the Beas, and the Sutlej, while that to the east of Simla flowed back by the long-established channels of the Jamuna, the Ganges, and other rivers into the Bay of Bengal. The upper course of the Siwalik river turned abruptly south to form the modern Brahmaputra. A remarkable evidence of reversal of flow of these rivers can be seen in the V-shape these rivers assume in certain portions of their course. The points of the V are in every case directed north-westwards. The boulders and pebbles embedded in a matrix of sand and clay accumulated in the neglected bed of the Siwalik river were ultimately uplifted and folded, resulting in a chain of hills, the Siwaliks of the present day.

Siwalik Animals. A great variety of mammals lived in the jungles and swamps of the Siwaliks, and their petrified remains have been discovered near Hardwar, Hoshiarpur, Potwar area in northern Punjab, and many other places in the Siwaliks. As many of them were the ancestors of our present-day animals, their study is of great interest to us. Nearly thirty species of elephants and elephant-like creatures have been described. Bones of many species of giraffes, hippopotami, rhinoceroses, horses, camels, antelopes, hyaenas, buffaloes, ostrich-like birds, crocodiles, tortoises and apes have been discovered. Odd creatures like *Siaatherium*, which combine the characters of the ruminants and pachyderms are of interest. This animal which has become extinct, was larger than a rhinoceros, had four horns and had a proboscis. A carapace of a giant tortoise, about 20 feet long, has been discovered. All these mammals were not of Indian origin. Central Africa is regarded as the home of pigs,

hippopotami, and elephants, from where they spread to India through Arabia and Iran by a land bridge during the late Tertiary. The rhinoceros, horse, and camel originated in North America, and came to India through Alaska, Siberia and Mongolia across Himalayan passes which were low and easily passable at that time. It is also significant that there were eleven genera of primates, some of which, like the *Dayopithecus* and the *Sivapithecus*, were closely related to the human stem.

THE HIMALAYAN RANGES

The Himalayas are a series of several more or less parallel or converging ranges, about 100 to 250 miles in width and 1,500 miles in length. Lengthwise, the Himalayas have been divided into four sections-the Pua jab Himalayas, from the Indus to the Sutlej, 350 miles long; Kumaooa Himalayas, from the Sutlej to the Kali, 200 miles long; Arepal Himalayas, from Kali to the Teesta, 500 miles long; and Assam Himalayas, from -the Teesta to the Brahmaputra, 450 miles long.

Breadthwise, the Himalayas can be divided into three zones: Inner Himalaya, Outer Himalaya and Siwalik. The Siwalik is a chain of lowlying hills, entirely made of fluvial deposits like sand, clay and rounded stones, extending from Assam to the Punjab. Most of the hill stations lie in the ranges of the Outer Himalaya, which is a strip 40 to 50 miles wide in Kumaon. The peaks in this zone are between 6,000 and 10,000 feet in height. Next is a zone about ten miles wide which, according to Burrard and Hayden, is occupied by spurs projecting southwards from the great range. Few peaks of this zone exceed 15,000 feet in height. Last of all comes the great Inner Himalayan zone of snow peaks and glaciers, the average height of which exceeds 20,000 feet, and which rise suddenly in the north like a wall of snow.

The core of the Inner Himalayan range is composed of rocks like granites, gneisses, and schists which are related to the Archaean gneisses of peninsula. 1Vlost of the high peaks of the Himalayas are either built entirely of granite or gneiss, or have substratum largely . composed of these rocks.

According to Burrard and Hayden, the Inner Himalayan range 'lies on a continuous zone of granite and associated crystalline rocks'. The granites belonging to several periods

welled up and intruded into the overlying sedimentary rocks, and brought about their metamorphosis into gneisses, schists, etc. The Outer Himalayas lying between the line of lofty peaks and the Siwalik zone are composed of 'series of fragmental rocks of undoubtedly sedimentary origin, such as slates, quartzites, conglomerates and limestone'. Entire absence of fossils makes correlation of these rocks with other Himalayan and extra-Himalayan beds very difficult. While they vary in structure from place to place, they are all thought to belong to the Purana formations, and are regarded 'as a northerly extension of what has been one of the most permanent as well as one of the oldest, continental areas of the globe', the Peninsula of India, which is a surviving fragment of Gondwanaland.

INDO-GANGETIC ALLUVIUM

The geotectonic stresses involved in the elevation of the Himalayas produced in the northern part of the peninsular foreland, a concomitant sag or depression at the foot of the mountains. This wide trough between the Vindhyan-Kaimur highlands and the northern mountains has, in the Eocene time, occupied by an arm of the sea, relics of which are found in the scattered chain of nummulitic outcrops, extending from Naini Tal to the Kala Chitta hills near the Indus. As the sea gradually retreated after the Eocene it was superseded by the broad estuary of the north-westerly flowing river which traversed the whole breadth of India from Assam to the north-west corner of the Punjab and then turned south to discharge its waters into the Sind Gulf. It was in this river basin that the Murree and Siwalik series were formed. This north-westerly drainage was disturbed in mid-Pleistocene time by differential earth movements and the old great river was split into the three separate river-systems of the Indus, the Ganges and the Brahmaputra. The depression still left began to be filled up by the silt brought down by the headwater tributaries of the Indus and the Ganges. Each fresh uplift of the mountains must have rejuvenated the streams, thus multiplying their carrying capacity and aggrading power. On emergence from the steep gradient of their mountain-track, these streams discharged their burden into the depression, eventually

filling it up and converting it into the low, flat, level plains of the Punjab, Uttar Pradesh, Bihar and Bengal.

Estimates about the depth of the alluvium in the Indo-Gangetic trough vary from 6,500 feet to 10,000 feet. The trough is not of uniform depth along its whole length; it is probably of maximum depth between Delhi and the Rajmahal hills, and shallow in Rajasthan and Assam. Nor is the floor smooth, for several corrugations and ridges have recently been observed underneath the alluvium by gravimetric surveys carried out by the Geodetic Survey of India. The northern rim of the trough, where it merges into the Himalayan foot-hill zone, is one of considerable tectonic strain; it is the site of the long parallel fractures of boundary fault type, and it is conceivable that the alluvium conceals a zone of similar folding and faulting further south. The seismic belt of India runs along the north margin of the plains. The epicentres of a majority of the great Indian earthquakes lie in this zone.

CHAPTER 4

SOILS

SOILS, in a general sense, refer to the upper layer of loose matter that covers the earth's crust. But from the agricultural point of view it may be defined as the material comprising more or less weathered rock minerals which, together with organic matter, water and air, provide a medium for the growth of plants. This medium is the basic source of all human and animal food.

The agriculture of a country is dependent to a large extent on the nature of its soils, which in turn, is influenced materially by climatic factors. Thus the soils of India, which extend from the temperate regions through the sub-tropical into the torrid, display marked differences in character which are again reflected in the vegetation pattern of the country.

But although soils undergo important secondary modifications through climate, topography, organic agencies etc., their fundamental character is determined by the general nature of the parent materials from which they have developed. Certain well-marked rock types give rise to certain definite types of soils; and variations in the rocks cause wide differences in the overlying soils in regard to their consistency, depth and composition.

The foundations of the soils of India have been classified into

- (1) Ancient crystalline and metamorphic rocks: The oldest rocks constituting the basement of Peninsular India which occur as granites, gneisses, crystalline schists, crystalline lime stone and subordinate rocks rich in ferromagnesian minerals. These rocks have given rise to red soils.
- (2) Cuddapahs and Vindhya: Being an ancient formation, the soils derived are all highly matured.
- (3) Gondwana: Occurs in the chains of basin-like depressions in the table-land of the peninsula filled with old river deposits, sands and silts. The Gondwana rocks have produced comparatively immature soils of less variety and fertility.

(4) Deccan Trap, comprising volcanic lava rich in ferromagnesian and alumina compounds. The typical soil derived from the Trap is the regur type or the black cotton soil.

(5) Mesozoic and tertiary sedimentary rocks of Extra-Peninsular India, occupying small areas of the hilly and mountainous ground in depressions and valley basins: (i) Mesozoic and Eocene calcareous rocks: and (ii) Tertiary sandy rocks.

(6) Recent and past recent rocks, which have given rise to the alluviums, entirely different in origin from the soils of southern India which are largely residual soils formed from the weathering products of rocks: old Indo-Gangetic alluvium; new Indo-Gangetic alluvium; deltaic alluvium; lateritic rocks; and desert deposits.

Meteorological conditions in India with their wide diversity, have given rise to major secondary modifications in the basic character of soils. The North has very different conditions from the South; the coasts present marked contrast to the interior; the climate of the West Coast region is different from that of the East Coast tract, and the Himalayan zone is a class by itself. The normal annual rainfall varies from about 460 inches in the Assam hills to less than three inches in Rajasthan. During some months of the year, vast areas are deluged; during others drought conditions prevail. Under the influence of such climatic variations, geological differences have ceased to be of predominant importance, and soils of similar properties cover the most varied rock systems. The more extreme the climate, the more generally will the climatic type of soil predominate. Examples are the black soils derived from different types of rocks. A mature soil is, therefore, to be regarded as the handi-work of geo-climatic and geo-biological forces operating jointly.

The climatic environment impresses itself most on the soils formed by river deposits and high winds. A good many of Indian soils are either 'transported soils' or belong to areas characterised by alternating periods of extreme aridity and humidity, in both cases the influence of climate often takes precedence over their geological character.

SOIL TYPES

The investigations of Voeleker in 1893, and of Leather in 1898, led to a classification of Indian soils into four major types: (i) Indo-Gangetic alluvium; (ii) black cotton or regur soils; (iii) red soils lying on metamorphic rocks; and (iv) laterite soils.

Indo-Gangetic Alluvium. This is by far the largest and most important of the soil groups of India. The soils of this group cover 3,00,000 square miles. They are distributed mainly in the northern, northwestern and north-eastern parts, including the Punjab, Uttar Pradesh, Bihar, Bengal, and parts of Assam and Orissa.

In spite of numerous subordinate variations, the main features of these soils derive from their having been developed from the material deposited by the numerous tributaries belonging to the Indus, the Ganges and the Brahmaputra river systems, which drain the Himalayas, bringing with them the products formed by the weathering of rocks.

Geologically, the alluvium is divided into: (i) Khadar, or new alluvium of sandy composition, generally light in colour, (ii) Bhangar, or the older alluvium of more clayey composition, generally of dark colour, and full of pebbles or kankar. The soils differ in consistency from drift sand to foams, and from fine silts of stiff clays. . A few pebble beds are also occasionally met with. . The presence of impervious clays obstructs the drainage, and also promotes the accumulation of injurious salts of sodium and magnesium whh make the soils sterile.

Formation of hard pans at certain levels in the soil profile as a result of the binding of soil grains by infiltrating silica -or calcareous matter is often observed in these alluvial soils. Layers of this kankar in the IndoGangetic alluvium of Uttar Pradesh and West Bengal are instances.of these hard pans.

The soils of the Punjab plains belong to the alluvial class typical of the Indo-Gangetic plains. A majority of soils are foams or sandy foams with a soil crust of varying depth. Hardly any horizon differences are observed in the profile. Soluble salts are present in considerable quantities. The lower layers contain kankar nodules. The soil character is generally alkaline due to

the presence of sodium in the clay complex. The soils are rich in phosphorus and potash, but are deficient in organic matter and nitrogen.

Two broad divisions are distinguished in Bihar: (i) alluvium found north of the Ganges, and (ii) alluvium found south of the Ganges. The soils in the first group are clayey, loam to sandy loam, neutral to alkaline in reaction, rich in potash, and deficient in P_2O_5 , while those in the second group are heavier and finer in texture, with higher K_2O and P_2O_5 contents, and of acidic reaction in the southern-most parts.

In West Bengal the Rarh tract consists mainly of old alluvium. There is hardly any regularity in the manner of deposition of riverborne materials. Some of the early deposits display considerable diversity on account of their long subjection to climatic and other influences.

In this group of soils may be included the alluvial soils of other river systems and also the coastal alluviums. The alluvial soils of Madras are transported soils, found mainly in the deltaic areas and on the coastal line. The profile shows alternate layers of sand and silt. The composition of the strata varies with the nature of the silt brought by the rivers which in turn varies with the catchment areas and the tracts through which the streams flow.

The light sandy red and yellow soils found in the Mahanadi basin are of alluvial origin. The formations in the North mainly Gujarat and on the west coast of Kerala consist mostly of the sands deposited from the sea. They are of low fertility.

Black Cotton or Regur Soils. The typical soil of the Deccan Trap is the regur or black cotton soil. It is common in Maharashtra, western parts of Madhya Pradesh, parts of Mysore and Madras, including the districts of Ramnad and Tirunelveli in the extreme South. It is comparable with the chernozems of Russia and with the prairie soil of the cotton-growing tracts of the United States of America, especially the black adobe of California. It is derived from two types of rocks: The Deccan and Rajmahal Trap, and the ferruginous gneisses and schists occurring in the Madras State under semi-arid conditions. The soils developed from the former sometimes attain considerable depth while those from the latter are generally shallow.

The black soil areas have, generally, a high degree of fertility, though some, mainly in the uplands, are of low productivity. The soils on the slopes and the uplands are somewhat sandy, but those in the farther plains are darker, deeper and richer, and are constantly enriched by deposits washed down from the hills.

Black soils are highly argillaceous, fine grained, and dark coloured, with a high proportion of calcium and magnesium carbonates. They very tenaciously hold moisture, and are exceedingly sticky when wet. Owing to considerable contraction on drying, large and deep cracks get formed during summer. They contain much iron and fairly high quantities of lime, magnesia, alumina, and potash. However, they are poor in phosphorus, nitrogen and organic matter. In all regur soils, in general, and in those derived from ferromagnesian schists, in particular, there is a layer rich in kankar nodules formed by the segregation of calcium carbonate at some depth below the surface and above the weathered rocks. The soils are generally rich in montmorillonitic and beidellitic groups of minerals.

In Maharashtra, soils derived from the Deccan Trap occupy quite a large area. On the uplands and on the slopes, the soils are light coloured, shallow and poor. On the lowlands and in the valleys, relatively clayey black soils are found. Along the Ghats, the soils are very coarse and gravelly. The soil is often some 20 feet deep in the valleys of the Tapti, the Narbada, the Godavari and the Krishna rivers. The sub-soil contains a good deal of lime. Outside the Deccan Trap area, the black cotton soil predominates in Surat and Broach districts. Degraded colonized black soils, locally known as chown, occur in the canal zones of the Bombay Deccan.

In Madhya Pradesh, two distinct kinds of black soils are found: (i) Deep heavy black soil covering the Narbada Valley, and (ii) shallow black soil. The cotton-growing areas generally have deep and heavy black soils, though soils of lighter texture are also found.

The black soils of Mysore are fairly heavy with high salt concentration. They are generally rich in lime and magnesia.

The black clay soils, popularly known as 'karail', which occur in the lower Gangetic basin in Uttar Pradesh are distinct from those of the Gangetic alluvium group, and show greater

resemblance to the regur 'of Central India. They possess a parent material similar to the black cotton soil. Their formation has been attributed to a transported basaltic type of alluvium received by the Ganges.

Red Soils. Red soils extend practically over the whole Archaean basement of Peninsular India, from Bundelkhand to the extreme south, an area of 8,00,000 square miles, embracing south Bengal, Orissa, parts of Central India, Madhya Pradesh, eastern Andhra Pradesh, Mysore and a major part of Madras. These also occur in Santhal Parganas in Bihar, and in Mirzapur, Jhansi and Hamirpur districts of Uttar Pradesh. They were produced as a result of weathering of ancient crystalline and metamorphic rocks.

The colour of these soils is generally red, grading sometimes into brown, chocolate, yellow, grey and even black. The redness is due more to a general diffusion than to a high proportion of the iron content.

The soils grade from the poor, thin, gravelly and light coloured varieties of the uplands to the much more fertile, deep, dark varieties of the plains and valleys. They are generally poor in nitrogen, phosphorus and humus. Compared to regur, they are poor in lime, potash and are also uniformly low in phosphorus content. The clay fraction of the soils is rich in kaolinitic type of mineral.

Red soils can be divided into two broad sub-groups: (i) teed foams of argillaceous character with a cloddy structure and possessing few concretions, and (ii) red earths with loose and friable top soil, rich in secondary concretions and sesquioxide.

More than two-thirds of the cultivated area in Madras is covered by red soils. They are in situ formations, produced from the rock below under the influence of climatic conditions. The rocks are acidic consisting of mica or red granites. The soils are shallow and open in texture. They have a low exchange capacity and are deficient in organic matter and plant nutrients. The $\text{SiO}_2/\text{R}_2\text{O}_3$ ratio of the clay fraction ranges from 2.5 to 3.0.

The predominant type in the eastern tract of Mysore is the red soil overlying granite. It is rich in potash, iron and alumina.

The acidic soils in the south of Bihar are red soils. In West Bengal, the red soils, sometimes misrepresented as

laterites, are transported soils from the hills of the Chhota Nagpur plateau. A part of Jhansi district in Uttar Pradesh also has red soils. A broad strip of area running between eastern and western parts of Coorg is red loam, easily drained, and having fairly dense vegetation.

Laterites. Laterite is a soil type peculiar to India and some other tropical countries characterized by intermittent occurrence of moist climate. In formation it varies from compact to vesicular rock composed essentially of a mixture of hydrated oxides of aluminium and iron and small quantities of manganese oxides, titania, etc. It is produced by the atmospheric weathering of several types of rocks.

Laterites may break and be carried to lower levels by streams. When re-deposited, they become cemented again into a compact mass by the segregative action of the hydrates. Thus, there are high level laterites resting on the rocks, and low level laterites formed in the usual way of detrital deposits.

Laterites are specially well developed on the summits of the hills of the Deccan, Mysore, Kerala, Madhya Pradesh, coastal region of Orissa, south Bombay and part of Assam. All lateritic soils are generally very poor in lime and magnesia, and deficient in nitrogen. Occasionally, the P_2O_5 content may be high, but there is deficiency of K_2O .

Forest and Hill Soils. The soil formation is governed mainly by the character of the deposition of organic matter derived from the forest growth. Broadly two conditions of soil formation may be distinguished : (i) Soils formed under acid condition, with acid humus and low base status, and (ii) soils formed under slightly acid or neutral condition, with high base status which is favourable for the formation of brown earths.

In Madras, there are both high level and low level laterites which are formed from a variety of rock materials under certain climatic and weather conditions. They are both in situ and sedimentary formations, and are found along the coastal region where rainfall is heavy and climate humid. The laterites in lower elevations grow paddy, while those in higher elevations grow tea, cinchona, rubber and coffee. The soils are rich in nutrients and contain 10 to 20 per cent organic matter.

In Coorg, laterite appears sporadically almost all over the country. In Maharashtra, it is found only in Ratnagiri. In the soils of Ratnagiri, coarse material is found in large quantities.

In Kerala, in between the broad sea belt consisting of sandy soil and sandy foams and the eastern regions comprising forest and plantation soils, the mainland contains residual laterite. It is poor in total and available P_2O_5 , available K_2O and CaO . Laterite in Cochin is found to the east of the alluvial areas.

The laterite soils of Mysore are comparable to the laterites found in Malabar, the Nilgiris, etc. The soils have very low lime content on account of severe leaching and erosion.

In West Bengal, the area between the Damodar and the Bhagirathi is interspersed with some basaltic and granitic hills with laterite capping.

In Bihar, laterite occurs principally as a cap on the higher plateau but is also found in fair thickness in some valleys. From the high values of the alkaline soluble silica and the SiO_2/R_2O_3 and SiO_2/Al_2O_3 ratios it appears to rest, 'in most cases, directly on gneiss or felsparic granite.

The laterites of Orissa are largely found capping hills and plateaus, occasionally in considerable thickness.

Other Soil Groups. In addition to the four principal groups of soils described above, mention may be made of four more groups. These are briefly dealt with below.

The soils of the hill district of Assam reveal high content of organic matter and nitrogen. This may be due to the virgin nature of these soils.

In Uttar Pradesh, the sub-Himalayan tract comprises three distinct parts, viz., Bhabar area immediately below the hills, Tarai and plains. The Tarai areas are characterized by extreme unhealthiness due to excessive soil moisture and prolific growth of vegetation.

The weathering of metamorphic rocks in Coorg has produced deep-surface soil of great fertility which receives annually the decomposed products of the virgin forest. The areas towards the west are for the greater part reserved forests and mountain areas. The land surface is full of pebbles, is easily drained, and has a laterite bed.

The cinchona-growing soils of West Bengal resemble brown earths: The surface layers, consisting of well decomposed

humus and mineral soil that shades off gradually and at varying depths into the colour of the parent rock, are strongly acidic in reaction. The high cation exchange capacity of these soils is due to the presence of high organic matter content.

Desert Soils. A large part of the arid region of Rajasthan and South Punjab, lying between the Sutlej and the Aravallis, is affected by desert conditions which, geologically are of recent origin. This part is covered under a mantle of blown sand, and is dominated by conditions which inhibit soil growth. Some of the soils contain high percentage of soluble salts and varying percentage of calcium carbonate, and possess high pH. They are, however, poor in organic matter. The limiting factor being mainly water, reclamation is possible if proper irrigation facilities are made available.

Saline and Alkaline Soils. These soils are extensively distributed throughout India in all the climatic zones. Many parts of the dry tracts of the North, especially in Bihar, Uttar Pradesh, the Punjab and Rajasthan, give rise to saline and alkaline efflorescences in the same way as the soils capping the upper tertiary rocks do. There are many yet undecomposed mineral fragments in these alluvial clay and silts which on weathering liberate sodium, magnesium and calcium salts. The injurious salts are confined to the top layers, being deposited there by capillary transference of saline solutions from the lower strata.

It has been estimated that 21 lakh acres in Uttar Pradesh and five lakh acres in the Punjab have been affected by usar. Twenty-five thousand acres a. e being affected every year in the Punjab alone. Methods of reclamation based on irrigation, application of lime or gypsum where necessary, and cultivation of salt-resistant crops like rice, berseem and sugarcane have been suggested.

Alkali soils are met with all over Maharashtra and Gujarat. A very large area has been affected due to the construction of Deccan canals. The belt round the gulf of Cambay has suffered on account of silt-lepos4s brought by tides. Nearly 67 thousand square miles, comprising the estuaries of the Narmada, Tapti, Mahi and Sabarmati have been damaged in this way. Such

soils show high content of exchangeable monovalent bases and magnesium, and a predominance of chlorides which amount to more than 50 per cent.

Peaty and. Marshy Soils. Peaty soils originate in humid regions as a result of accumulation of large. quantities of organic matter. They may contain, in addition, considerable amount of soluble salts. Such typical peaty soils abound in Kerala. They are black, heavy and highly acidic. The acidity is due to decomposition of organic matter under anaerobic condition, and no nitrification is possible.

The depressions formed by dried river basins and lakes in alluvial and coastal areas sometimes give rise to peculiar water-logged and anaerobic conditions in the soils. Such soils are generally blue coloured due to the presence of ferrous iron, and contain varying amounts of organic matter. Marshy soils of this type are found in the coastal tracts. of Orissa, in the Sundarbans and some other places in Bengal, in the Central portion of north Bihar, in the Almora district of Uttar Pradesh, and on the south-east coast of Madras.

FERTILITY STATUS OF INDIAN SOILS

The poverty of Indian soils is an undisputed fact. The low crop yields have posed a serious problem to the whole planning endeavour in which the country is engaged, and call for an immediate solution.

Indian soils, like all tropical soils in general, are very deficient in organic matter and nitrogen. The phosphate deficiency is comparatively less marked, while potash deficiency is rare.

In sizing up the situation it has been felt that there is an urgent need for promoting the use of nitrogenous fertilizers on a large scale in all parts of the country. Application .of these, especially in conjunction with phosphatic fertilizers, has been found to increase, crop yields very considerably. As regards potash, the general experimental evidence appears to suggest that most Indian soils, barring laterites, are relatively well supplied with potassium. But there is need for further investigation to determine the scope for its use as a fertilizer. Recently, the trials carried out on cultivators' fields by the Bihar

State Agricultural Department have indicated the need for potash manuring for stepping up the production of most of the agricultural crops in the State. Similarly, in Kerala State, potash manuring of paddy soils in the form of wood-ash. has been found to be quite beneficial.

The extremely poor content of organic matter in the soils has led to the popularity of green manures, for it has been found that cowdung and other bulky organic manures are not available in adequate - quantities. Green leaves and wild leguminous plants serve very well for the purpose. In the North, berseem, particularly, is finding favour with the cultivators, for not only it helps in building up soil fertility but is also very valuable as a fodder crop.

CHAPTER 5

CLIMATE

AGRICULTURE IS conditioned by many 'controls' of which weather, which is of Nature's devising, is the most inexorable. Agricultural meteorology attempts to study it in all its complexity so that proper planning may be possible and the avoidable risks guarded against.

In India the success of agriculture, which is the main industry of the people, depends principally on the monsoon rains. We have reliable weather records for the past 75 years, which are of great practical value in understanding the trends that Nature generally follows. The important questions to be considered are: (i) What is the dependability of rainfall in different parts of this vast sub-continent; (ii) how often in a century is the monsoon rainfall so markedly excessive (flood) or deficient (drought) as to cause widespread havoc and failure of crops; and (iii) besides the vagaries of the monsoon, what are the other major weather risks to agriculture? These must be pondered over if we are to plan our agricultural development on sound lines.

PHYSICAL AND CLIMATIC FEATURES

Figure 3 presents a very clear picture of the distribution of the annual rainfall in India. The areas of very heavy rainfall are to the windward side of the Western Ghats, the hills of Assam, and the great Himalayan barrier. These are the watersheds from which originate the major river systems of the country. Elsewhere, in the plateau of the Deccan, the Gangetic plains of North India, and the plains of South India, the effects of orography are less pronounced or are completely absent, and the rainfall is only moderate. In the north-west, the Punjab, Rajasthan, and the adjoining tracts to the north and west constitute the driest area of the country.

Table on page 31 gives the normal rainfall in different seasons of the year and during the year as a whole in the

various sub-divisions of India. For our present purpose the year may be divided into four seasons, viz., winter (December to February), summer or pre-monsoon period (March to May), monsoon (June to September), and post-monsoon period (October to November). In columns two to five, the figures within brackets indicate the seasonal rainfall expressed as percentage of the annual rainfall.

It will be seen that India is truly the land of monsoons. With the exception of Kashmir and south-east Madras, a very large percentage of

NORMAL SEASONAL RAINFALL (INCHES) IN VARIOUS RAINFALL SUB-DIVISIONS OF INDIA

Sl. No.	Sub-division	Winter (December to February)	Summer or Pre- monsoon (March to May)	Monsoon (June to September)	Post- monsoon (October to November)	Full year
1.	Assam	2.38(2.4)	25.06(25.7)	64.26(65.8)	5.96(6.1)	97.66
2.	W. Bengal	1.53(2.0)	12.42(16.)	56-01(74.5)	517(6.9)	75.13
3.	Orissa	1.82(3.2)	5.62(9.9)	44-49(78.2)	4,.98(8.8)	56.91
4.	ChhotaNagpur	2.57(5.0)	3.64(7.1)	42.71(83.)	2.26(4.4)	51.18
5.	Bihar	1.41(2.9)	3.30(6.8)	40-96(850)	2.54(5.3)	48.21
6.	U. P. East	1.53(3.9)	1.12(2.9)	3444(88.0)	2.04(5.2)	39.13
7.	U. P. West ..	2.27(6.0)	1.36(3.6)	3298(87-8)	0.97(2.6)	37.58
8.	Punjab E. & N.	2.76(11.9)	1.89(8.1)	18.23(78.4)	0.371 1.6)	23.25
9.	Punjab S.W.	1.28(13.7)	1.36(14-5)	6.58(70.4)	0.13(1.4)	9.35

10. Kashmir	9.12(22.1)	0.09(22.0)	22.19(53 .7)	0.94(2.3)	41.34
11. Rajasthan W.	0.62(4.8)	0.56(4.3)	11.74(90 .0)	0.12(0.9)	13.04
12. Rajasthan E.	0.96(3.8)	0.78(3.1)	22.91(90 .9)	0.55(2.2)	25.20
13. Gujarat	0.22(0.7)	0.24(0.7)	31.46(96 .2)	0.77(2.4)	32.69
14. C. India West	0.85(2.5)	0.47(1.4)	31.56(93 .8)	0.75(2.2)	33.63
15. C. India East ..	1.44(3.7)	0.79(2.0)	35.05(90 ..9)	1.30(3.4)	38.58
16. Berar	1.01(3.1)	0.96(3.0)	28-10(87.4)	2.07(6.4)	32.14
17. C. P. West	1.47(3.2)	1.14(2.51)	41.04(90 .4)	1.76(3.9)	45.41
18. C. P. East	1.58(3.0)	2.10(4.0)	46.37(89 .1)	1.99(3.8)	52.04
19. Konkan	0.28(0.3)	1.85(1.7)	102.45(9 3.7)	4.75(4.3)	109.33
20. Bombay-Deccan	0.51(1.7)	2.13(6.9)	24.41(79 .1)	3.82(12.4)	30.87
21. Hyderabad N.	0.67(1.9)	1.53(4.4)	29.51(84 .5)	3.20(9.2)	34.91
22. Hyderabad S.	0.57(1.9)	2.10(7.0)	23.38(78 .1)	3.88(13.0)	29.93
23. Mysore	0.73(2.0)	5.47(15.2)	22.27(61 .8)	7.54(20.9)	36.01
24. Malabar	2.73(2.6)	12.61(12.2)	71.47(68 .9)	16.3(16.3)	103.74
25. Madras S.E.	4.76(13.6)	4.53(12.9)	12.01(34.2)	13.80(39.3)	35.10
26. Madras-Deccan	0.74(3.0)	2.42(9.9)	15.27(62 .3)	0.09(24.8)	24.52
27. Madras Coast N.	1.69(4.2)	3.44(8.9)	25.03(62 .3)	10.11(24.9)	40.16

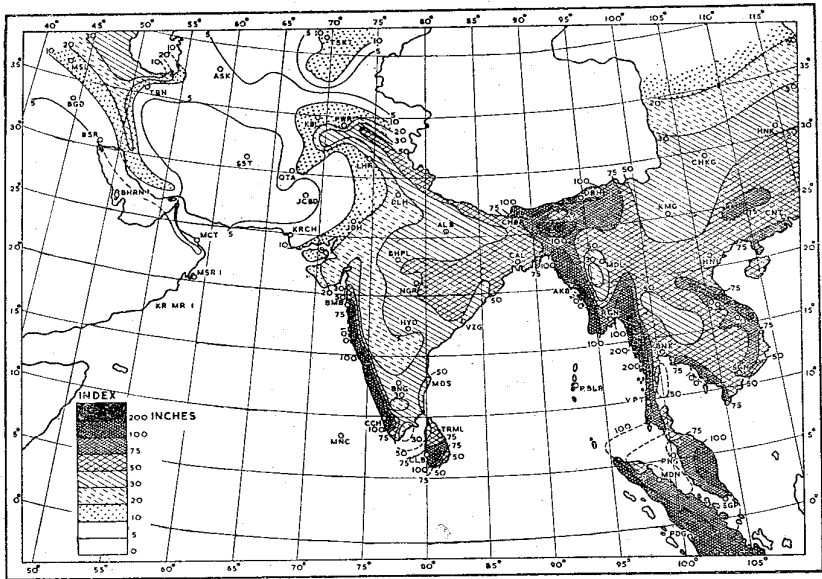


FIG. 3. Annual rainfall in India

the annual rainfall over the country occurs during the South-West Monsoon period (June to September). In the extreme North, a good proportion of the annual rainfall is contributed by winter precipitation, while in southeast Madras nearly half the annual rainfall occurs during the post or retreating monsoon period (i.e., after September).

MONSOONS

With the advance of summer, associated with the 'no-thing' of the sun, insolation increases rapidly over the higher latitudes so that by the end of May, the region of the highest air temperature and the lowest atmospheric pressure lies over north-west India and the adjoining areas of Pakistan, Afghanistan, Persia and Central Asia. This low pressure system takes over _ control, as it were, of the air currents over Asia, so that the South-East Trade Winds from the south of the Equator after being diverted into the Arabian Sea and the Bay of Bengal, appear suddenly over the west coasts of India and Burma respectively, as the South-West Monsoon. The Arabian Sea

branch of the South-West Monsoon, while crossing the Western Ghats, gives copious precipitation over that region, and continues to drift eastwards across the Deccan and central parts of the country, meeting the bay branch of the monsoon along the trough of low pressure which extends from Orissa to north-west India. The bay branch is deflected by the Arakkan Yomas and turned in its course so as to skirt the northern side of the low pressure trough while moving along the sub-montane tracts to the south of the great Himalayan barrier.

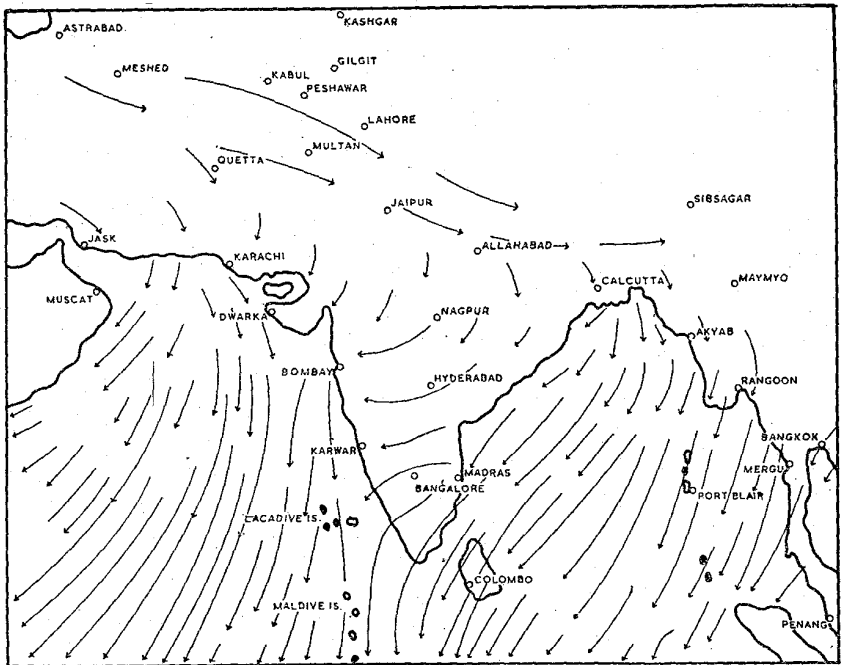


FIG. 4. Average wind currents in January

It should not be imagined that the monsoon behaves as a steady phenomenon. If that were so, the rainfall would have been always orographic, i.e., to the windward side of the mountain barriers along the West Coast, the Arakkan mountains, and the Himalayas. Fortunately, the monsoon currents pulsate with a series of eastern depressions, originating in or reviving over the head of the Bay of Bengal, and moving in a westerly to

northwesterly direction across the northern and central India. These depressions occur at intervals during the monsoon season, and divert the humid currents into the central and north-western tracts, thus bringing about a more equitable distribution of rainfall all over the country. Figure 5 shows the average wind currents in July when the monsoon is usually most vigorous. Besides the above variations in the intensity of the monsoon, there are also temporary breaks when rainfall tends to decrease in the plains and persist in the Himalayan tracts.

By mid-September, the South-West Monsoon rapidly withdraws from the country and is termed the 'retreating monsoon'. This gradually leads to the north-easterly air current assuming full sway over the sub-continent and the adjoining seas by January (Fig. 4). The North-East Monsoon, as it is called, is associated with rainy weather over the southern parts of Peninsular India, particularly over Tamilnad, from November to the end of January.

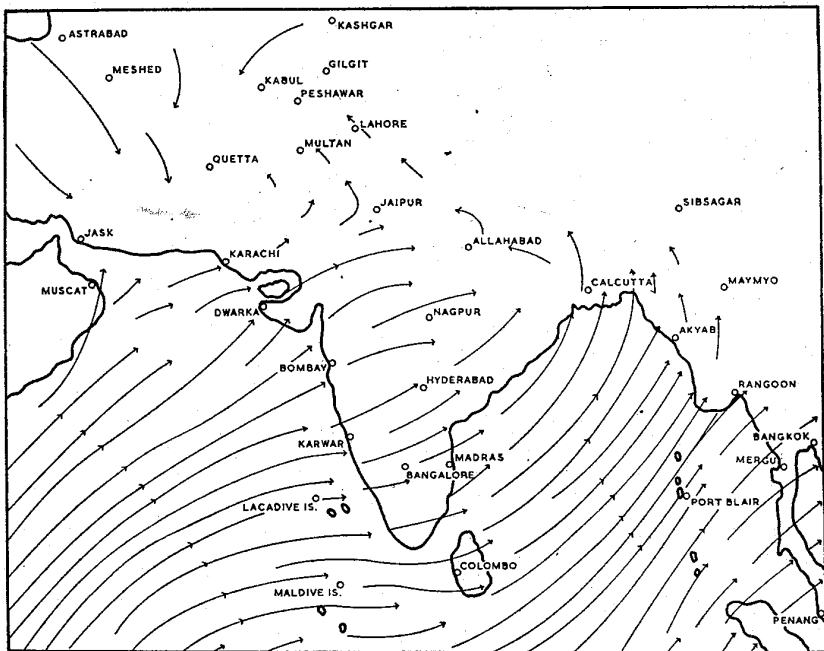


FIG. 5. Average wind currents in July

Eastern Depressions. Fluctuations in the intensity of the monsoon are to a very large extent associated with a series of depressions which mostly originate from (or, when they are coming from farther east, are strengthened at) the head of the Bay of Bengal, and travel in a northwesterly direction across the country towards north-west India, causing heavy rainfall along their track. The frequency of such depressions is three or four per month during the monsoon period (June to September). In some years, the frequency of these depressions comes down very much, and then the monsoon rainfall tends to become 'orographical' (i.e., confined to the hills and mountains). This shows the importance of the depressions for securing proper spatial distribution of the rainfall over the plains of northern and central India. In years of few depressions, droughts occur in the interior regions of the country, chiefly in the north-west and central parts.

Western Depressions. During the period November to May, a series of western depressions enter India through the North-West Frontier and Baluchistan, and move eastwards across North India towards northeast India (Assam-Bengal). These depressions cause cloudy weather and light rains in the plains, and snowfall in the Himalayas, and are followed by cold waves. The frequency of these western depressions is, on an average, two in November, four to five per month during December to April, and about two in May.

Cyclonic Storms. The more severe cyclonic storms usually form in the Bay of Bengal and the Arabian Sea during the transition periods, i.e., April to June, and October to December. They enter inland and cause considerable precipitation and damage due to high winds and, occasionally, tidal waves in the coastal tracts. The mode of occurrence of these storms and depressions and their favourite tracks. have been discussed at length in the publications of the Indian Meteorological Department. On an average, one or two severe cyclones may be expected in the pre-monsoon period, and two or three in the post-monsoon period.

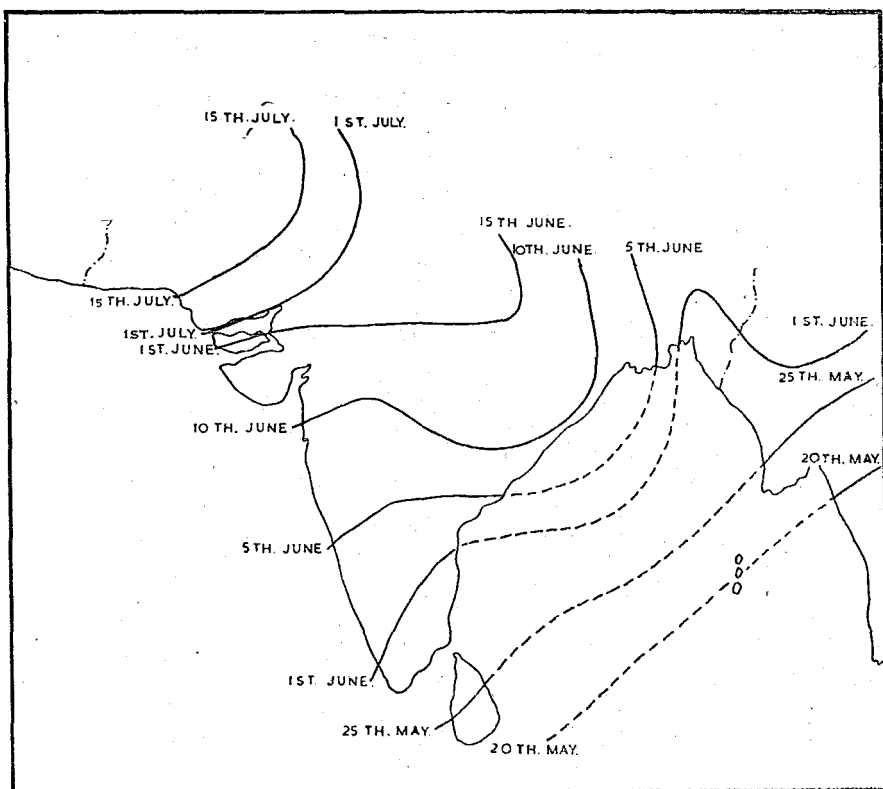


FIG. 6. Normal dates of onset of South-West Monsoon

South-West Monsoon. The Indian farmer waits anxiously for the onset of the monsoon, and prays for a timely and suitable distribution of rainfall during the season. Figures 6 and 7 show the usual dates of the outbreak and withdrawal of the monsoon in different parts of the country. These as well as the intensity and distribution in time and space of the precipitation vary from year to year. Table on page 37 gives the actual dates of the onset of the South-West Monsoon in four areas along the West Coast of the Peninsula. Table on page 39 summarizes this information. Considerable variation is noticed not only with regard to the establishment of the monsoon but also in the speed with which the currents move from Kerala area towards Kolaba in the north.

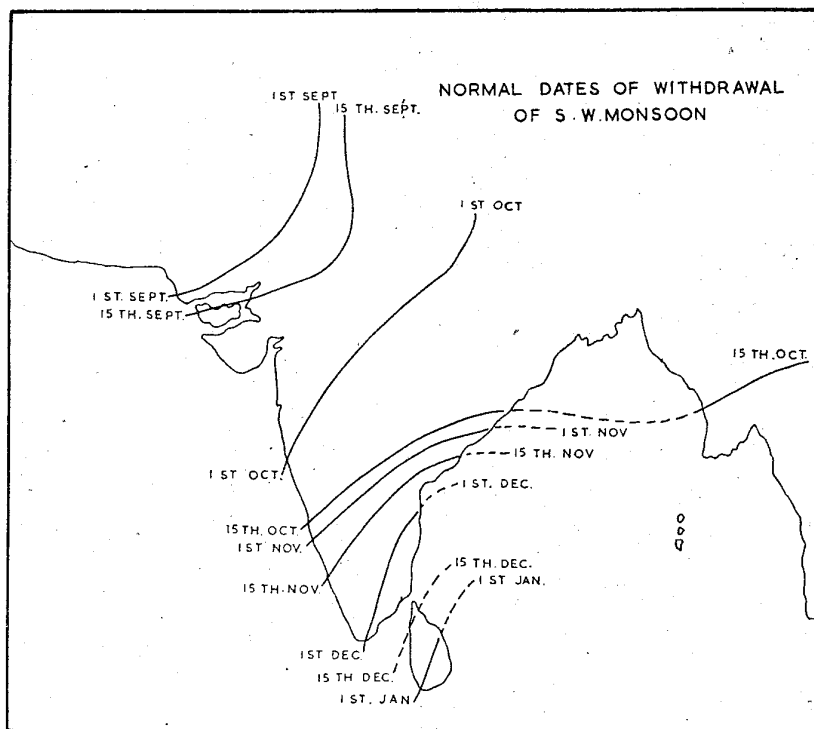


Fig. 7. Normal dates of withdrawal of South-West Monsoon

As the major agricultural operations have to synchronize with the monsoon rains, prediction of the date of their establishment in different parts of the country, and the spells of rain and of breaks during the season, is of great importance to agriculture.

This problem has been investigated by Ramdas and co-workers. The following world-weather factors are found to have some influence on the 'date of establishment' of the South-West Monsoon:

(1) Rainfall in the Seychelles in the preceding April (positive).

DATES OF ESTABLISHMENT OF SOUTH-WEST MONSOON
ALONG WEST COAST OF INDIA

Year	Kerala	S. Kanara	Ratnagiri	Kolaba
1891	May 27	June 3	June 19	June 21
1892	22	May 24	May. 29	May 31
1893	22	June 4	June 10	June 10
1894	June 1	2	7	7
1895	8	12	14	15
1896	May 30	May 31	1	1
1897	30	June 5	7	7
1898	June 2	3	8	8
1899	. May . 23.	7	9	10
1900	June 6	8	9	19
1901	1	4	7	7
1902	May 31	6	7	12
1903	June 8	11	12	12
1904	May 29	1	7	8
1905	June 6	8	9	10
1906	3	6	7	8
1907	May 31	5	11	11
1908	June 8	10	11	11
1909	11 1	2	3	3
1910	May 28	2	3	3
1911	June 1	2	4	4
1912	4	6	12	12
1913	May 24	1	6	7
1914	28	5	13	13
1915	June 3	12	17	18
1916	May 26	May 27	May 31	1
1917	26	29	June 4	5
Year	Kerala	S. Kanara	Ratnagiri	Kolaba
1918	May 7	May 15	May 22	May 25
1919	16	26	June 4	June 6

1920	27	June 2	6	6
1921	1	3	10	12
1922	25	May 31	10	12
1923	4	June 11	12	13
1924	31	3	June 10	12
1925	27	May 28	May 29	May 29
1926	28	June 5	June 9	June 10.
1927	May 23	May 27	June 10	June 10
1928	33	31	5	7
1929	29	30	1	6
1930	21	June 7	8	9
1931	23	May 29	14	14
1932	14	June 2	3	3
1933	22	May 28	1	1
1934	June 6	June 6	10	10
1935	11 10	11 10	12	14
1936	May 28	May 22	May 29	1
1937	June 3	June 10	June 11	12
1938	1	2	2	4
1939	6	6	7	9
1940	7	13	16	18
1941	May 23	3	14	1E
1942	June 4	June 8	June 12	12
1943	May 12	May 14	May 21	May 21
1944	17	30	June 8	June 1(
1945	..	..	11 12	11 11

(2) Mean west winds over Agra (1KM-2KM-3KM) during the fir; half of the preceding May (positive).

3) Darwin (Australia) pressure the preceding April (positive).

(4) Difference of pressure between Cochin and Jaipur during the preceding April (negative).

(5) South Rhodesian rainfall during the preceding period, October to April (negative).

(6) South Rhodesian rainfall during the preceding April (negative).

Forecasting formulae, expressing departures from the norm of the date of establishment as simple linear functions of the departures of four or more of the above factors, have been worked out for: (a). the West Coast as a whole, (b) the northern half of the West Coast, and (c) the southern half of the West Coast. These formulae are being tested for the last few years.

DATES OF ESTABLISHMENT OF SOUTH-WEST MONSOON ALONG WEST COAST OF INDIA

Area	Mean date	Standar d deviatio n (in clays)	Earliest date	Latest date
Kerala	May 29	7.0	May 7	June 10
South Kanara	June 3	5.7	15	12
Ratnagiri	7	5.4	22	19
Kolaba	8	5.2	25	21

”

Monsoon Behaviour. To begin with, we may consider the total rainfall during the entire South-West Monsoon season, i.e., from June to September. If the deviation of the actual precipitation in a year in a subdivision is more than twice the mean, that year may be defined as a year of flood or drought according as the departure is positive or negative. Generally speaking, the number of floods and droughts tend to equalise over long periods. It is the area with very low rainfall, e.g., Rajasthan which experiences the greatest number of abnormalities. On the other hand, in areas like Konkan, Malabar, Bengal, etc., where the monsoon rainfall is above 40 inches, abnormalities are fewer. These features are clear from Table on page 40.

The years 1877, 1899 and 1918 stand out prominently as years of general drought. Such countrywide droughts occur once in about 20 years. It may be recalled that these were actually the years of great famine and distress. In 1920 there was a partial drought, only the north-west and the central parts of the country being affected. The years of general flood were 1878, 1892 and 1917. There is, however, no regular periodicity in the occurrence of floods and droughts. Moreover, the chances of a drought (or flood) being succeeded by another, in a particular sub-division, appear to be small.

DEVIATION FROM NORMAL RAINFALL

Sl. No.	Name of sub-division	Normal rainfall (June to Sept.) Inches	Limit for deviation for abnormality Inches	Number of abnormalities in 75 years		
				Floods	Droughts	Total
1.	Assam	64.3	10.0	6	4	10
2.	W. Bengal	56.0	10.0	3	4	7
3.	Orissa	44.5	10.0	1	3	13
4.	Chhota Nagpur	42.7	10.0	1	3	4
5.	Bihar	41.0	10.0	10	11	21
6.	U. P. East	34.4	10.0	13	10	23
7.	U. P. West	33.0	10.0	6	11	17
8.	Punjab E. & N.	18.2	6.0	14	11	25
9.	Punjab S. W. ..	6.6	4.0	11	4	15
10.	Kashmir ..	22.2	6.0	4	13	217
11.	Rajasthan W. ..	11.7	6.0	11	10	21

12	Rajasthan E.	22.7	10.0	9	6	15
13	Gujarat ..	31.5	14.0	9	9	18
14	Central India W.	31.6	10.0	10	4	14
15	Central India E.	35.1	15.0	4	6	10
16	Berar	28.1	10.0	10	6	16
17	C. P. West .	41.0	10.0	11	10	21
18	C. P. East	46.4	10.0	9	6	15
19	Konkan .	102.5	28.0	3	9	12
20	Bombay Deccan	24.4	7.0	6	6	12
21	Hyderabad N	29.5	10.0	9	6	15
22	Hyderabad S.	23.4	9.0	10	7	17
23	Mysore	22.3	8.0	4	1	5
24	Malabar	71.5	20.0	7	4	11
25	Madras S. E. .	12.0	4.0	7	7	14
26	Madras-Deccan	15.3'	7.0	7	6	13
27	Madras Coast N.	25.0	7.0	10	1	11
			Mean	9	7	16

SEASONAL FEATURES OF RAINFALL, TEMPERATURE, HUMIDITY

We may now turn to more detailed time-studies of rainfall distribution. ~'or this, the rainfall data published regularly in the

Weekly Weather Reports of the Indian Meteorological Department are very useful.

An ideal year would be one in which there are no droughts or floods. Successful crop production depends not only on the total seasonal rainfall, but also on the proper distribution of the precipitation in time and space. Even a sub-normal rainfall may, if well distributed, produce a good yield. Some spells of drought and flood are to be expected in most years; and if these are of short duration, the season's total rainfall is not materially effected. However, once in about 5, 10 or 20 years, (depending on the area concerned) the 'drought' or 'flood' extends over a number of consecutive weeks. Such prolonged spells, particularly at the critical stages of crops, cause widespread damage.

The winter season begins earlier and lasts longer in North India than in the central and southern tracts, the duration as well as the intensity of the cold decreasing rapidly as one moves towards the Equator. In northeast India and the maritime tracts of the Peninsula, seasons of high humidity are long. During summer, before the onset of seasonal showers, relative humidity is lower than 40 per cent in the interior, which is continental in character. These are the tracts where the familiar wet khar-khas seasons can be effective in bringing down room temperatures during summer.

WEATHER ABNORMALITIES AND CROPS

The progression of weather factors during a season is never smooth and regular. On any day, or in any week or month of the year, the actual weather factors deviate at random and in varying degrees from the normal value. Often, weather fluctuations occur abruptly and with a violence which crops can hardly stand. The weather, benevolent up to a degree, has sometimes a malevolent aspect for the crops. The major weather abnormalities and destructive meteorological phenomena which affect crops adversely in India are: floods (excessive rains); droughts (scanty rains); storms, depressions and untimely rains; thunder-storms, hail-storms and dust-storms; heat waves; cold waves and frost; excessive or defective insolation; and high winds.

Floods. The meteorological records show that:

- (1) Falls exceeding 5" in 24 hours have occurred over the whole of India.
- (2) Falls have exceeded 10" in 24 hours over most of the interior of the Peninsula and of Burma, and in a few districts in the central parts of the country.
- (3) Falls of 15" to 20" in 24~hours have occurred all along the West Coast including Gujarat and Kathiawar, on the south Coromandel Coast, on the north Burma Coast, in south Assam, in Bengal, and at the foot of the Himalayas.
- (4) A few isolated falls of 20" and over in 24 hours have occurred in the plains.
- (5) The largest fall of 40" in 24 hours has occurred at Cherrapunji in the Khasi Hills. .

When heavy rainfall occurs continuously over a number of days, particularly in the catchment areas of rivers, the magnitude of the resulting floods is enormous. Indiscriminate and wholesale destruction of forests which has taken place in the past has contributed in very large measure to the flood problem. The importance of a well developed forest cover over a catchment area for checking erosion and preventing flood conditions cannot be over-emphasized. The State Forest Departments are now devoting special attention to afforestation as part of the flood control measures that are being devised. Side by side flood-resistant varieties of crops are also being evolved.

Droughts. Rainfall is more variable in areas where it is scanty; and the problems created by droughts or prolonged dry spells relate first of all, to the careful collection of rain water in tanks, bunds, lakes, etc., and its distribution by a planned system of irrigation. There are also problems relating to the conservation and economical use of available water. Wherever feasible, resort should be had to sub-soil irrigation, i.e., delivering water at the root-zone of plants through suitable pipes. In arid parts like Rajasthan, such a system would prevent water losses from evaporation which would occur in the case of surface irrigation. Evaporation Control Research, using molecular film of cetyl or stearyl alcohol or a mixture of them, has recently been initiated

at a few centres by the Council of Scientific and Industrial Research, with the cooperation of the irrigation officers concerned. Methods of conserving sub-soil moisture by surface mulching are in use in dry farming tracts where droughts are the rule. In such areas the soil has a high water-holding capacity. It is possible also to check air movements near the ground by building up a system of wind breaks in order to reduce losses by evaporation. In areas susceptible to droughts, drought-resistant varieties of crops and plants should be introduced.

Cyclonic Storms and Depressions. One of the features of the cyclonic storms and depressions is that their favourite directions and speed are generally of determinate nature so that the dates of their onset over ; region and the associated heavy rains and squally weather can be forecast. People engaged in shipping; aviation, railway engineering, and irrigation are alerted against bad weather. Agriculturists also take advantage of these warnings by trying to save standing crops, stored grain, livestock etc; Warnings of untimely rain and heavy rain, especially during the sowing and harvesting times are particularly useful. Against large-scale floods and very severe squalls the cultivator can do little, but if fore-warned, lives can be saved.

Thunder-storms, Hail-storms and; Dust-storms. These are comparatively local in character, although they may also be associated sometimes with depressions, storms, etc., which affect a bigger area. They usually occur before the onset and after the withdrawal of the monsoon. In their mode of occurrence, thunder-storms, dust-storms and hail-storms have much in common. In the absence of sufficient moisture in the atmosphere we can get only a dust-storm. When enough moisture is present, a thunder-storm occurs. A hail-storm is a particularly violent thunder-storm. Though short in duration, the precipitation and associated squalls during thunder or hail-storms are often very violent. Squalls of up to 80 to 100 miles speed per hour in short spells may sometimes occur. In many parts of India, e.g., in the Deccan, pre- and post-monsoon thunder showers are the :vain sources of soil moisture for growing crops.

Hail-storms are, however, very destructive to standing crops, and even to livestock and human beings. Weather records show that the frequency of hail-storms is small in early winter but increases generally as the season advances into summer. Once

the monsoon sets in, these disappear practically. After the withdrawal of the monsoon, hail-storms begin to occur in the North and central parts of India, but their frequency remains low till spring. The frequency in the Himalayan region is about ten per year. This decreases rapidly to one in two years over the adjoining plains. In lower Bengal the hail-storms occur usually once a year. Madhya Pradesh is another area where, on an average, hail-storms occur once a year. In the coastal tracts of the Peninsula, hail-storms are comparatively rare.

The largest known, hail-stones are about 5 inches in diameter, weighing about 1 lb. Hail-stones have been reported sometimes to break through ordinary roofs, corrugated iron sheets, etc. Protection against violent storms is, therefore, difficult, particularly under rural conditions.

Cold Waves and Frost. During winter, atmospheric disturbances, called Western Depressions, enter India from the west at intervals of about a week, and move eastwards through the Indo-Gangetic plains and the central parts of the country towards the North-East Frontier. The approach of a depression is heralded by the appearance of high clouds, movement of air from southerly latitudes, and rise of air temperature. Within a day or two, the clouds lower and drizzling ensues. So long as the place lies in the warm sector of the depression, there is no danger of low temperatures, but the warm sector moves eastwards and is soon followed by a cold wave, when cold dry winds from the North or North-west, up to about 4,000 feet in depth, pour into the region. The cold wave moves across the country, weakening in the meantime. The intensity as well as the extent of a cold wave depends on the intensity and the area of the depression with which it is associated. Sometimes, the anti-cyclone over Tibet and Mongolia, which is the main reservoir of cold air for Asia, is itself shifted westwards towards Europe, and if about that time a western depression passes through Persia and north-west India, a very severe cold wave sets in behind the depression. The phenomenal cold wave which visited India in 1929 from January 29 to February 3, was of this type.

It is known that topography has much to do with the degree of immunity of a locality against frost. The bottom of a valley collects all the cold air flowing during the night -f: 3m the neighbouring slopes. The farmer should try to avoid such localities for growing crops which are susceptible to cold. Slopes

are less liable to frosts as cold air cannot collect on them; they are, therefore, to be preferred for locating horticultural gardens.

During cold waves the country is often swept by strong currents of cold winds. In the case of important cash crops like vines and sugarcane, particularly, it is necessary to try heating the orchard by means of artificial heaters, after reducing the air movement by means of wind-breaks. At Nasik, experiments conducted by the Agricultural Meteorological staff showed that by using 400 country fires per acre and with wind-breaks of jowar stalks it was possible to warm up the air in the garden by about 10° F., which is sufficient to prevent freezing on a frosty night. However, in the case of short crops like wheat it is more difficult to alter the local climate by artificial heating or smudging. Irrigation as a protective measure may be useful during short cold waves. During protracted spells, however, a considerable amount of solar heat is lost by evaporation from the wet soil, and the protection afforded by irrigation tends to be counteracted. The damage done by frost is very extensive in some years, as is borne out by the large revenue remissions granted by the States in Northern and Central India.

Heat Waves. Just as cold waves are injurious to crops in winter, heat waves in summer are also deleterious. The centre of high frequency of maximum temperatures of 100° F. and over lies over the Deccan and the central parts of the country during March, April and May. The frequency increases from 20 days in March to 30 days in May over the Deccan, but after the onset of the monsoon the focus of high temperature shifts rapidly towards north-west India. However, in July and August, south-east Madras is another area of high temperatures.

Excessive or Defective Insolation. Insolation is a function of the inclination of the solar rays, length of the day, and transparency of the atmosphere. On clear days in summer, the temperature of the ground surface in India rises very high, particularly if air movement is weak. Readings of the order of 167° F. are often recorded over black soils. Some experiments made at Poona show that on such days a thin cover of a white substance like chalk can depress soil temperatures at noon by as much as 36° F. A black cover (e.g., charcoal powder), on the other hand, is useful for absorbing the insolation fully on heating up the soils in times of weak insolation. The effect of wetting the surface is to depress soil surface temperatures by about 27° F.

But the cooling effect is due to heat loss by evaporation and lasts only as long as there is enough moisture in the surface layers of the soil. A thin layer of chalk or a surface mulch of ' bagasse ' helps not only to keep the soil layers cool but also to conserve soil moisture. The fundamental importance of clear sunshine to photo-synthesis in plants is well known. During cloudy weather this activity is decreased and plant growth is retarded. Also, conditions. become favourable for the incidence of certain pests and diseases if such weather is unseasonal.

High Winds. The effects of high winds are many. The physical effect and the resulting damage to standing crops are obvious. For example, a crop of jowar would be laid low if high winds blow in October when it stands full. In winter the cold winds aggravate the rigors of the season, and if frost sets in the damage to crops is heavy. In summer the hot winds intensify the rate of evaporation from water reservoirs, and also increase enormously transpiration from plants. and trees. Plants wilt and die owing to rapid desiccation. The shrivelling effect of hot winds on grains at the. milk stage is also very disastrous.

It is necessary that the unbridled sweep of winds over fields should be checked. Wind-breaks are the only remedy. These should consist of a line of trees planted at right angle to the prevailing wind direction. When the trees grow up, the gaps must be blocked by growing another line of younger trees or shrubs. An ideal, wind-break for checking wind currents would have the .contour of an earth-dam. In the central rows would be planted the tallest trees; on either side, rows of shorter trees, and outside of these, low bushes. Such a wind-break would not be easily penetrated and its inclined surface would direct the air currents upwards and relieve the wind pressure.

The advantage of a wind-break consists in:

- (1). Checking air movement and thus affording protection to fields and orchards;
- (2) Checking the movements of top soil (wind erosion) and consequent prevention of dust-storms in areas with sandy or very fine soil,;
- (3) Reducing evaporation: This happens in two ways, viz., by reducing wind velocity and by decreasing saturation deficiency;
- (4) Providing shade for the farm structures; and

(5) Providing fuel and timber.

It is found that the loss due to the area taken up by wind-breaks and due to the water removed from the fields by the root systems of the trees and shrubs is more than offset by the increase in crop yields of the protected area and by the value of fuel and timber.

During severe atmospheric disturbances like cyclonic storms, depressions, thunder-storms, etc., squalls or very high winds are experienced. It may be noted that exceptionally high wind pressures are experienced mainly in the coastal tracts.

WEATHER SERVICE

The success of Indian agriculture depends mainly on favourable weather. The farmer, therefore, must have the forecasts of weather and other natural phenomena like floods as early as possible. This would enable him to adjust his operations to the anticipated weather conditions during the sowing season and to take steps to protect his standing crops from natural calamities. Accordingly, the Indian Meteorological Department inaugurated a 'Weather Service' for the farmer in July, 1945.

It is designed to help the farmer to know when the monsoon rains are likely to begin, how the rainfall would vary during the season, when breaks are expected, and when there will be resumption of wet weather: Such information will enable him to time suitably the various cultural operations like preparation of seed beds, manuring, sowing, inter-culture, weeding, transplanting, harvesting, threshing, drying, etc. If conditions are favourable during the first phase (germination and early vegetative growth) the crop gets a good start. Thereafter, intervals of clear weather are required for inter-culture and weeding. During the second phase or the 'grand period' (rapid vegetative growth) a crop requires more water and sunshine. In the third phase (flowering and reproduction) vegetative growth ceases. This period of flowering, and grain formation needs clear weather and minimum cloudiness. Cloudy, wet weather at this stage can ruin a promising crop. When the ear-heads are forming and the grains are in the milk stage, the grains would shrivel if hot winds blow even for a day. Even at the end of a favourable season a crop is not safe till it is harvested. A heavy

shower of rain or hail can do heavy damage. If warned in time the farmer would hasten his harvesting operations. Later, when the harvested crop is lying on the threshing floor, it is again at the mercy of sudden showers. The advantages of the Weather Service to the farmer are thus, obvious.

Farmers' Weather Bulletins are issued daily by the Regional Forecasting Centres and broadcast by the All-India Radio stations in the regional languages in their rural programmes. The number of A.L.R. stations broadcasting such bulletins has been increasing rapidly.

The need for improving the network of observatories in India was realised at the very commencement of the 'Weather Service for Agriculture'. The accuracy of detailed forecasts depends to a considerable extent on this network. The problem of increasing the number of observatories has been engaging the attention of the Meteorological Department since 1945 and new stations are being opened progressively.

Weather requirements vary from crop to crop and from locality to locality. Detailed information received from the agricultural departments has been condensed and presented in pictorial form in 'Crop Weather Calendars'. These calendars have already been distributed to the Regional Forecasting Centres of the Meteorological Department at Bombay, Calcutta, Delhi, Madras and Nagpur for their guidance in issuing daily Farmers' Weather Bulletins for their areas. For getting a relatively more objective picture of weather conditions for the country as a whole, weekly charts of rainfall, temperature, humidity and crop growth are also compiled.

The meteorologist is endeavouring hard to help the agriculturist in reducing risks with which weather factors baffle his entire labour. But his present knowledge imposes rigid limitations on his work. Thus, forecasts and warnings can generally be issued only 36 to 48 hours in advance though in the case of major phenomena associated with storms and depressions predictions may be possible 48 to 72 hours ahead. Again, phenomena like thunder-storms and hail-storms are often very sporadic in their distribution, and it may not always be possible to predict them accurately. When the monsoon conditions have not been established, and the monsoon is late in arriving (or when there is a break), it may be possible to indicate

only in a general way whether the cultivators will get rain within the range of a few days. But even this forecasting, which comes under the category of ' Medium Range Forecasting ' has yet to be developed considerably before it can be truly serviceable. These problems are receiving urgent attention.

CHAPTER 6

VEGETATION

INDIA possesses a greater variety of vegetation than any other country. This is because of her geographical position (8' N. to 37' N. lat. and 63' E. to 97'5 E. long.) as well as variations in altitude and climate. Immigration of plants from countries like Malaya, China; Japan, Siberia, Arabia, Africa and Europe has also contributed to the variegated character of her flora. However, except in very high altitudes and dry desert areas, the vegetation is essentially arboreal in character.

A comparison of the Indian flora with those of adjacent countries indicates that the Malayan element is the dominant type. The European element is represented in the Western Himalayas by several genera and species. The African element comes next in the order of dominance. The Tibetan and Siberian types are confined to the Himalayas, and comprise mainly alpine herbs and shrubs. The Chinese and Japanese flora are strongly represented throughout the Temperate Himalayas by many oaks and rhododendrons.

The vegetation types which are described in this chapter concern largely the trees and shrubs under Phanerogams together with a few Gymnosperms which give character to our forests. Algae, Fungi, Bryophytes and Pteridophytes are omitted. The account is based on the work of Sir J. D. Hooker, Gamble, Brandis, Dudgeon, Kashyap, Champion, Chaturvedi and Chatterjee, as well as, on the personal observations of the author. Some of the main types alone have been considered here. It must, however, be mentioned that even though there is little difficulty in recognising the several well-marked types, the border line of each is not always easy to determine, as one type of forest often tends to merge into the other. It may be mentioned that within the areas under each type of vegetation the occurrence and predominance of species are considerably influenced by physical factors such as altitude, climate, soil, etc.

I. TROPICAL EVERGREEN VEGETATION

These forest types are developed in regions of very heavy rainfall and are characterized by the great variety and luxuriance of their vegetation, composed largely of dense mesophytic evergreens. Many trees attain great heights and, girths, and in these forests, three or four canopy layers or storeys are noticeable, dependent on the varying heights of the trees. Some species develop also characteristic buttressed stems at base.

Generally, the tree trunks are densely clothed with thick felts of leafy jun-germanniales and mosses. The ground in these forests is usually covered with a dense growth of shrubby vegetation and ferns. Large woody climbers, tree-ferns, palms, bamboos and cane-breaks are also characteristics of these forests. Epiphytes are common.

Typical evergreen forests are to be found along the West Coast of Peninsular India, particularly on the western face of the Western Ghats, Eastern Sub-Himalayan tracts, Upper Assam, Chittagong . Hill tracts and at Andamans on the upper slopes of the hills:

West Coast Region. This covers the Konkan, Kanara, Kerala State, Annamalais and the Nilgiris. The greater part of it is hilly and mountainous, and the western face of the Western Ghats supports a dense vegetation of Malayan type chiefly represented by the families Sterculiaceae, Tiliaceae, Anacardiaceae, Meliaceae, Myrtaceae, Melastomaceae, Vitaceae, Gesneraceae, Piperaceae, Zingiberaceae, Orchidaceae and Araceae. The species commonly met with in this region are: *Dipterocarpus indicus*, *Hopea paraiflora*, *Hopea wightii*, *Calophyllum tomentosum*, *Cullenia rosayroana*, *Palaquium ellipticum*, *Dysoxylum malabaricum*, *Syzygium cumini*, *Actinodaphne unguistifolia*, *Canthium dicoccum*, *Terminalia chebula*, *Carvia callosa*; *Toona ciliata*, *Tateria-indica*, *Canarium strictum*, *Tetrameles nudiflora*, *Mesua ferrea*, *Mangifera indica*, *Pterygota alata*, *Acrocarpus fraxinifolius*, *Olea dioica* and *Pouteria tomentosa*.

Palms are represented by solitary species of *Arenga*, *Caryota* and *Corypha* with the cultivated *Areca catechu* and *Cocos nucifera* in places. Among undershrubs, *Strobilanthes* is important, and many species are noted for flowering at long intervals of four to six years to twelve or even fifteen years.

Among herbaceous plants *Impatiens* with about 60 species is conspicuous. In mountain torrents in the Ghats, *Podostemonaceae* occur.

Eastern Sub-Himalayan Tract. This includes Sikkim, and the regions eastwards of the low country bordering on the spurs of Eastern Sub-Himalayan Range and its slopes, and, extending into the plains, Upper Assam and Cachar. It is most humid, supporting a tropical flora up to an altitude of about 5,000 ft. The tropical evergreens are represented by species such as *Michelia champaca*, *Schima wallichii*, *Artocarpus chaplasha*, *Dillenia indica*, *Talauma hodgsoni*, *Aesculus punduana*, *Terminalia tomentosa*, *Terminalia myriocarpa*, *Salmalia malabarica*, *Pterospermum acerifolium*, *Cinnamomum glanduliferum*, *Canarium sikkimensis*, with canes, climbers and an impenetrable undergrowth of evergreen shrubs.

At lower elevations, *Allanodia* sp. and *Michelia champaca* are met with and at higher elevations *Castanopsis indica*, *Alnus nepalensis* and *Bucklandia populnea* are found.

In the Sub-Himalayan Tract of Bengal and adjoining regions of Assam, however, the typical wet evergreen is only locally recognisable in places. Sal forests have established in much of the area rendering the type as one of wet-mixed forests. This is to be found in east Nepal, north Bengal and along the slopes of Garo, Khasi, and Jaintia Hills of Assam. In these areas the associated species with Sal are: *Michelia champaca*, *Schima wallichii*, *Anogeissus latifolia*, *Terminalia tomentosa* and *Dendrocladus hamiltonii*; and in the Tista valley of Sikkim, *Garuga pinnata*, *Terminalia belerica*, *Schima wallichii*, *Lagerstroemia paraiflora*, *Tetrameles nudiflora*, *Sterculia alata*, *Toona ciliata*, *Bauhinia purpurea*, *Mallotus philippensis* and *Callicarpa arborea*.

The Andamans. The climate of Andamans is warm and equable. The vegetation shows a greater resemblance to that of Burma. On the upper slopes of the hills and on micaceous sandstone sub-strata in south and middle Andamans, evergreen forests are met with. *Dipterocarps* predominate with many species. The most characteristic trees are: *Dipterocarpus tuberculatus*, *D. turbinatus*, *D. alatus*, *D. incanus*, *D. gracilis*, *Artocarpus chaplasha*, *Artocarpus gomeziana*, *Calophyllum soulattri*, *Planchonia andamanica*, *Hopea odorata*,

Etadospermum malaccense, *Sideroxylon longipetiolatum*, *Garcinia andamanica*, *Myristica andamanica*, *M. glaucescens*, *Pterospermum acerifolium*, *Mitrephora epraiiai* and *Anaxagorea luzonensis*.

The ground, cover is composed of a dense undergrowth of canes and other climbers as *Calamus palustirs* and *Genetum montanum* and the climbing bamboo *Dinorchloa andamanica*.

II. TROPICAL SEMI-EVERGREEN VEGETATION

These types of forests are usually characterized by the deciduous species also occurring mixed with the evergreens. The leafless period of these forests is very short. Such forests are usually found adjoining the tropical evergreen forests detailed earlier. They are to be recognised along the Western Ghats, considerable parts of Assam and lower slopes of Eastern Himalayas, Brahmaputra and Surma Valleys, and also locally in the Andamans.

Western Ghats. In this region, in places, good deal of teak grows on the lower slopes of the hills which are covered with evergreen types as *Dalbergia latifolia*, *Artocarpus*, *Polyalthia* and *Tillaria*. The deciduous associates are *Terminalia paniculata*, *Xylia xylocarpa*, *Stereospermum personatum*, *Trewia polycarpa*, *Lagerstroemia lanceolata*, and *Schleichera oleosa* with *Bambusa arundinacea* as the representative bamboo in the lower storey. The ground cover includes various species of *Rubiaceae*, *Acanthaceae*, canes and climbers.

Eastern Himalayas, Assam and Brahmaputra and Surma Valleys. Along the Eastern Himalayas and in upper Brahmaputra and Surma, Valleys, this forest type is represented by *Meliaceae*, *Lauraceae*, *Myristicaceae*, *Magnoliaceae* and others. The following species are typical of the lower slopes of the hills in Upper Assam to north of Brahmaputra and Naga Hills to the south of the river: *Dipterocarpus macrocarpus*, *D. gracilis*, *Artocarpus chaplasha*, *Shorea assamica*, *Cinnamomum cecidodaphne*, *Dysoxylum binectariferum*, *Altingia excelsa*, *Mesua ferrea*, *Pterygota alata*, *Michelia champaca*, *Amoora spectabilis*, *Toona ciliata* and *Kayea assamica*.

Along the lower slopes of Cachar, Khasi and Jaintia Hills and around Surma Valley are found: *Dipterocarpus turbinatus*, *D. macrocarpus*, *Pterygota alata*, *Mesua ferrea*, *Salmalia insignialis*, and *Artocarpus chaplasha*, *Quercus* spp. (oak) are also found in these belts.

The northern Bengal region is characterised by *Schima-Bauhilaia* in association with *Toona ciliata*, *Stereospermum tetragomm*, *Ailanthus grandis*, *Castanopsis indica*, *Tetrameles nudiflora*, *Michelia champaca* and *Gmelina arborea*. The undergrowth is composed of *Phoebe*, *Machilus*, *Anaora*, *Actinodaphne*, *Mesua* and *Polyalthia*. Bamboo thickets of *Bambusa arundinacea*, *Doodrocalamus hamiltonii*, *Oxytenanthera nigrociliata* and *Melocanna bambusoides* are also noticed in these forests.

Andamans. In Andamans, the semi-evergreen as also the deciduous forests are developed on the lower slopes of hills and in regions between the mangroves and beach-forest and the evergreen forests. In south and middle Andamans, they are also found on metamorphosed and indurated clay, shale and conglomerate, limestone and sandstone sub-strata. The most important timber trees of these forests are: *Pterocarpus dalbergioides*, *Lagerstroemia hypoleuca*, *Terminalia bialata*, *T. maianii*, *Albizia lebbek*, *Careya arborea*, *Adenanthra* and *Paaonina* with palms, canes and shrubs as undergrowths, but not dense.

III. TROPICAL DRY EVERGREEN VEGETATION

Along the east Coromandal Coast of Deccan in the Carnatic, and not far into the interior, but within the reach of the damp sea breeze, the dry evergreen type of forest is developed as a narrow strip. This region receives the full benefit of the North-East Monsoon. The best forests are found at Nellore, Cuddapah and north Arcot. The forest type is characterised by low and stunted, but dense dry evergreen vegetation. Several small leaves and thorny species also predominate in this belt. The trees characteristic of this forest type are: *Chloroxylon srivietenia*, *Diospyros ebenum*, *D. melanoxylon*, *Strychnos nux-vomica*, *Mimusops elengi*, *M. hexandra*, *Soymida febrifuga*, *Memecylon edule* and among the evergreen thorny shrubs may

be mentioned *Randia*, *Canthium*, *Ficus*, *Flacozertia* and *Dichrostachys*.

IV. TROPICAL DECIDUOUS VEGETATION

Unlike the evergreen forests, these forests are typically characterised by the predominance of deciduous species. These forest types are found spread over the greatest parts of India, and different kinds are recognisable in different regions, ranging from moist-deciduous or monsoon forests, and dry-deciduous to tropical thorn forests. In some of the moist-deciduous and dry-deciduous forests sal predominates and the thorn forests are distinguished by low, open, pronouncedly xerophytic forests in which the thorny *Acacia* spp. and *Prosopis* spp. predominate. The following are some of the deciduous types met with in our country.

Moist-deciduous Forests. This type is recognisable in the lower Gangetic Plains, in eastern Uttar Pradesh, Bihar; Orissa, Assam and West Bengal, on the eastern face of Western Ghats and the Andamans.

Lower Gangetic Plains. This region is characterised by humidity and luxuriant vegetation. The extreme moist type of sal is to be seen in Bengal and Assam, and excellent quality is produced in West Bengal, Kurseong, Tarai up to Tista Valley. Mango groves are plentiful in this region with fig, bamboo, betel-nut, palmyra and phoenix palms. Coconut also grows extensively. The predominant trees in Uttar Pradesh are *Madhuca latifolia* and *Mangifera indica*. Other characteristic trees are: *Michelia champaca*, *Polyalthia longifolia*, *Salmalia malabarica*, *Lagerstroemia speciosa*, *Pterospermum acerifolium* and *Ceiba pentandra*.

Western Ghats. In this region species of considerable economic importance grow, such as *Tectona grandis*, *Dalbergia latifolia*, *Grewia leptopetala*, *Xylia xylocarpa*, *Terminalia paniculata*, *Lagerstroemia lanceolata*, *Pterocarpus marsupium*, *Adina cordifolia*, *Mitrogyna Javanica*, with *Sehleichera* and *Careya*. The bamboos are represented by *Bambusa arundinacea*, *Dendrocalamus strictus* and *Oxytenanthera monostigma*. The undergrowth consists of *Lantana*, *Clerodendron* and *Helicteres isora* and more frequently grass.

Andanzans. The moist deciduous forests of the Andamans otherwise known as 'Padauk' forests, like the moist sal and moist teak forests of the mainland, occupy low level (below 300 ft.) localities, which either have less rainfall, or coarse, porous soils derived from sandstone. The transition from the evergreens is imperceptible. The species characteristic of this region are: *Pterocarpus dalbergioides*, *Canarium euphyllum*, *Sterculia campanulata*, *Salmalia insignis*, *Tetrameles nudiflora*, *Albizia lebbek*, *Adenanthura pavonina*, *Oxytenanthera nigrociliata*, *Terminalia bialata*, *Terminalia malabarica*, *Terminalia procera*, *Lagerstroemia hypoleuca*, *Chukrasia tabularis*, *Lanea coromandelica*, *Dillenia pentagyna* and species of *Bambusa*.

The ground cover is composed of *Rinorea bengalensis*, *Mallotus acuminatus*, *Tentiliga madraspatana*, *Tetracera scandens* and *Acacia pennata*.

Deccan Region. In this connection, a reference is also to be made of a mixed type of moist and dry deciduous forests occurring in the Deccan, in various parts of Madhya Pradesh, Orissa (south of Mahanadi), Andhra Pradesh, Madras and Mysore and parts of Maharashtra and Rajasthan. Teak occurs at intervals nearly all over the area. Much of the open country presents a jungle of small trees and shrubs, together with a herbaceous vegetation which is leafless or burnt up in the dry season. *Chloroxylon swietenia* (satinwood) and *Pterocarpus santalinus* (red sanders) yield the most ornamental of Indian timbers. *Toona ciliata* (Toon) is one of the most useful timbers. *Santalum album* (sandalwood) is widely distributed over the southern part of the area: The rich black cotton soil that is found over large areas in the Deccan deserves special notice as being characterised by a peculiar assemblage of the indigenous plants of the region. The list of common trees is *Capparis diversifolia*, *Acacia arabica*, *Prosopis spicigera*, *Parlinsmia aculeata* and *Balanites aegyptiaca*. The narrow strip of low lying land between the Eastern Ghats of the Deccan and the sea is dry and hot and in many tracts, sandy.

Farther south, teak is less common and in many places absent, owing perhaps, to past human exploitations. *Terminalia* spp. and *Anogeissus* spp. are associated with *Acacia catechu*, *Chloroxylon swietenia*, *Gleistanthus collinus*, *Hardwickia binata*, *Boswellia serrata* and *Soyimida febrifuga*. The ground cover is

composed of grasses usually species of *Andropogon*, *Paizicum* and *Aristida*.

Dry-deciduous Forests. These consist of low forests almost entirely of deciduous trees in all canopies. The following regions support similar type of forests.

Upper Gangetic Plains. This includes Rajasthan, east of the Aravalli Hills, Bundelkhand, Malwa and western Uttar Pradesh. The indigenous vegetation of this sub-region is that of a dry country. The trees in the dry season are leafless for the most part and the grasses and herbs get dessicated and burnt up in the hot season. The principal forest is that of Ajmer, flanking the Aravalli and other hills which bound the sub-region on the west. The average rainfall is 25 inches. After the close of cold months, temperature rises rapidly in the month of March and humidity goes down. High temperature shooting up to 114° F. in the shade and dessicating hot west winds from the rocky Aravalli Hills and sandy deserts of Rajasthan, often accompanied by dust-storms in May and June have produced a typical desert vegetation of xerophytes with adaptations against dry conditions and with devices for conserving moisture. The commonest trees are the leafless *Capparis decidua*, *Salvadora oleoides* with tough leathery leaves, *Acacia arabica*, *Prosopis spicigera*, *Balanites aegyptiaca*, *Diospyros cordifolia*, *Ficus rumphii* and several species of *Tamarix* with reduced scaly leaves. The wastelands between the villages are more or less barren with only occasional patches of *zizyphus* *7zummularia* and *Salvadora persica*. Others more or less restricted to western India are *Morbzga oleifera*, *Acacia senegal* and *Prosopis spicigera* accompanied by the common trees of the drier parts of India, especially *Butea monosperma*. Considerable areas of this sub-region are occupied by the *usar* or *reh* land which, being impregnated with alkalies, are converted into swamps in the rainy season and into deserts in the dry season. *Salvadora fiersica* and *Butea monosperma* are the only trees that succeed on saline soils. The rocky areas are covered with hardy shrubs like *Anogeissus pendula*. Among the herbaceous vegetation we find such interesting xerophytes as *Leptadeizia spartium* with erect cylindrical almost leafless branches, the spiny *Alhagi camelorum* and the deep rooted *Arizebia lizspidissinza*. In the shade of the prickly bushes of *Capparis sepiaria* grows the inconspicuous droughtresistant *Ceropegia bulbosa*, whose

bulbous perennating stem is roasted and eaten by cowherds. Besides these, we find succulent herbs like *Portulaca oleracea* and *Salsola feotida*, which store up a large quantity of water in their leaves, and rosette plants with tough perennating root-stocks like *Boerhaavia diffusa* and *Euphorbia tilmifolia*. Of the herbaceous plants a few perennial rooted grasses are the only ones which thrive.

Central India. The commonest species are *Anogeissus acuminata*, *A. latifolia*, *Erythrina suberosa*, *Mangifera indica*, *Syzygium cumini*, *Albizia odoratissima*, *Boswellia serrata*, *Lannea coromandelica*, *Sterculia urens*, *Terminalia belerica*, *Ficus glomerata* and *F. religiosa*. The most conspicuous trees are *Boswellia serrata* and *Sterculia urens*. When in leafless condition, *Boswellia serrata* with its peculiarly twisted branches and yellow stem is a remarkable sight. Its wood is used for manufacture of match boxes, match sticks and paper pulp. *Sterculia urens* yields gum katira which is used in cosmetics. The commonest bamboo is *Dezdroclamus strictus* which is also used for manufacture of paper pulp. The following trees comprise the lower canopy of these forests: *Mallotus philippensis*, *Flacourtia ramoztchi*, *Carissa spinarum*, *Embllica officinalis*, *Wrightia tomentosa*, *Bauhinia retusa*, *B. raceynosa*, *Caesaria tomentosa*, *Butea monosperma*, *Holoptelea integrifolia* and *Dendrocalamus strictus*.

South-east Deccan. This region comprises the Carnatic, the Eastern Ghats, Madras, a large part of Andhra- Pradesh and Mysore. The vegetation is of a dry, thorny, stunted type. The commonest species are *Acacia planifrons*, *A. sundra*, *Mimusops* sp., *Azadirachta indica*, *Albizia amara*, *Acacia latronum*, *Dichrostachya cinerea*, *Chloroxylon swietenia*, *Prosopis ;pil:gera*, *Salmalia insignia* and *Osyris arborea*. Fleshy evergreen *Euphorbia* sp. also constitutes a characteristic feature of the vegetation. *Cassia azcriculata* and *C. fistula* occur here and there, and the chief among the thorny shrubs are *Capparis* sp., *Carissa spinarum*, *Aristida adscensionis* and *zizyphus* sp.

Carnatic. The forests in this region form an intermediate stage between the monsoon and xerophytic forests. The commonest forest tree is sandalwood. Other representatives are *Tectona grandis* and associated *Terminalia* app. and *Anogeissus latifolia*. Other species include *Dillenia pentagyna*, *Kydia calycina*, *Lagerstroemia lanceolata*, *Adina cordifolia*, *Madhuca latifolia*,

Grewia asiatica, *Pterocarpus marsupium*, *Lannea coromandelica*, *Salmalia malabaricum*, *Butea mozzosperma*, *Bridelia retusa*, *Diospyros melanoxylon* and *Emblica officinalis*. The chief bamboo is the well-known commercial variety *Dendrocalamus strictus*. Grasses are plentiful, including *Eulaliopsis binata*, *Moghania* spp., with *Milletia auriculata*, *Lantana* and *Carissa spinarum*.

Tropical Thorax Forests. This is typically characterised by a xerophytic forest of low and open formations with many species adapted to xerophytic conditions. Thorny trees and plants are very common. This type of forest is distributed over the Indus Plain region in southern Punjab, Gujarat, Rajasthan, the Upper Gangetic Plains and in Deccan Plateau.

Indus Plain Region. This includes the Punjab, Gujarat and Rajasthan to the west of the Aravalli Hills. With few exceptions, all trees in this region have deciduous leaves, and most of the herbs are dessicated and burnt in the hot season. Vegetation in this region is typically xerophytic. The principal indigenous trees are: *Tamarix articulata*, *Sterculia wrens*, *Grezoia salicifolia*, *Aegle marmelos*, *Moringa oleifera*, *Dalbergia sissoo*, *Butea monosperma*, *Pyosopis spicigera*, *Acacia arabica*, *Salvadora persica*, *Salvadora oleoides*, *Anogeissus pendula*, *G"ordia myxa*, *Terminalia tomentosa*, *Tecnmella undulate*, *Ficus Mfectoria* and *Mortis in'dica*.

Of shrubs, among the most conspicuous are isolated clumps of the columnar, almost leafless *Euphorbia royleana* and *E. neriifolia*. Of special interest in this region are two species of cotton, *Gossypium stocksii* and *G. zoightianum*. The other more or less prevalent shrubs and undershrubs in certain districts are: *Capparis aphylla*, *G. horrida*, *C. spinosa*, *Flacourtia ramontchi*, *Taznarix dioica*, *Tamarix gallica*, *Greroia* sp., (seven species), *Fagonia arabica*, *Rhamnus persica*, *R. virgata*, *zizyphus nummzilaris*, *z. vulgaris*, *z. oenoplia*, *Dodorzoea viscosa*, *Alhagi maurorum*, *Sophora mollis*, *Cassia auriculata*, *C. tore*, *C. obovata*, *Mimosa rubicaulis*, *Pluchea lanceolata*, *Reptonia buxifolia*, *Carissa diffusa*, *Rhazya stricta*, *Nerium odorum*, *Orthanthera viminea*, *Periploca aphylla*, *Calotropis procera*, *C. gigantea*, *Withania coagulans*, *Adhatoda vasica*, *Calligonum polygonoides*, *Pteropyrum olivieri*, *Salsola foetida* and species of *Kochia*. Fleshy *Suaeda* and *Salsola* grow on saline soils and *Calligonum polygonoides* on sandy soils.

In the Thar Desert fleshy *Euphorbia neriifolia* is the most characteristic species. Trees are also indicators of soil to a large extent. *Salvadora persica* Linn. and *Prosopis spicigera* Linn. grow on loamy soil. *Tamarix articulata* grows on saline soil and in areas where it grows, wells too have saline and bitter water. *Butea monosperma* grows on user and reh lands impregnated with calcium bicarbonates on which no other trees can thrive.

Rajasthan. The trees found in the xerophytic forests of Rajasthan are with reduced leaf surface or with fleshy leaves. Various species of *Acacia* and *Prosopis*, the commonest being *Acacia arabica* and *Acacia leucophloea* and are associated with *Prosopis spicigera* and the exotic *Prosopis juliflora*. *Acacia catechu* is found in considerable quantity in Cutch. In the southern Aravallis, *Anogeissus pendula* occurs in fairly homogeneous patches. Other typical species are *Salvadora oleoides*, *Tamarix articulata*, *zizyphus jujube*, *Greivia populifolia* and " *Ehretia laevis*. The undergrowth consists of *Capparis aphylla*, *Capparis spinosa*, *Asclepias* and *Calotropis*, with the fleshy *Suaeda* and *Salsola* growing on saline soils, and *Calligonum polygonoides* on sandy soils. *Euphorbia nivulia* with a thorny stem is also very characteristic at the foot of the dry mountains.

The dry vegetation of the Upper Gangetic Plains, and that of the Deccan Plateau have already been alluded to earlier under tropical drydeciduous forests. In these regions, the characteristic species are the leafless *Euphorbias* and other drought-resisting species, and the thorny and spiny plants such as *Acacia arabica*, *Prosopis spicigera*, *.Zizyphus rotundifolia*. *Alhagi camelorum*, *Cabparis sepiaria*, *C. aphylla*, etc.

V. SUB-TROPICAL MONTANE VEGETATION

These types of forests are to be recognised along the lower slopes of the Himalayas in Bengal, Assam, and locally in other hill ranges as Khasi Hills, the Nilgiris and the Mahabaleshwar Hills. . These forests, are characterised generally by tall luxuriant trees with evergreen species predominating.

In the Nilgiris, the Annamalais, the Palni Hills and Travancore Ranges, above 5,000 ft. and extending . up to 8,000

ft. altitude, a characteristic type of evergreen forest occurs, locally known as 'sholas'. The trees in these sholas are comparatively of small size with more or less rounded crowns. The undergrowth is also rich, and species of *Strobilanthes* and bracken fern are frequent. *Rubus*, *Rhododendron* and other species of a temperate climate characterize these sholas as sub-tropical to temperate types. The characteristic trees are: *Michelia nilagirica*, *Ternstroemia japonica*, *Eurya japonica*, *Gordonia obtusa*, *Meliosma wightii*, *Photinia notoniana*, *Cinnamomum zeyheri* and *Euonymus crenulatus*.

At lower elevations, however, *Mesua ferrea*, *Hitex altissima*, *Artocarpus lakoocha*, *Dysoxylum malabaricum* and *Hydnocarpus alpina* occur.

Another strip of sub-tropical forests is to be noticed throughout the Central and Western Himalayas, between 3,000 ft. and 6,000 ft., characterised by open chir-pine forests, with or without evergreen underwood vegetation. They are locally developed at similar elevations at Khasi Hills also.

Yet another type, characterised by dry evergreen xerophytic thorny species and small leaved evergreens of olive trees, leading up to Savannah and mountain grasslands is to be found in the north-west part of India.

At lower elevations these forests merge into tropical evergreen types, but at higher altitudes, they run into the temperate type of forests.

VI. TEMPERATE VEGETATION

The temperate forests are to be seen at higher elevations along the Eastern Himalayas, between 6,000 ft. and 10,000 ft., in the Central and Western Himalayas between 5,000 ft. and 10,000 ft., and on the inner ranges of the Himalayas, throughout their length, and locally also on the hills in South India. According to the type of temperate forest found in particular regions, the composition of these forests consists, generally, of evergreen or semi-evergreen mixed forests, deciduous species, conifers, oaks, pines, spruce, deodar, junipers, and xerophytic broad-leaved trees. The undergrowth may be dense and evergreen, or sparse and partly deciduous or open scrub

undergrowth. In favourable areas, even bamboo brakes are to be noticed.

The following are some of the types of temperate forests noticed in our country.



FIG. 8. Evergreen forests in Kerala

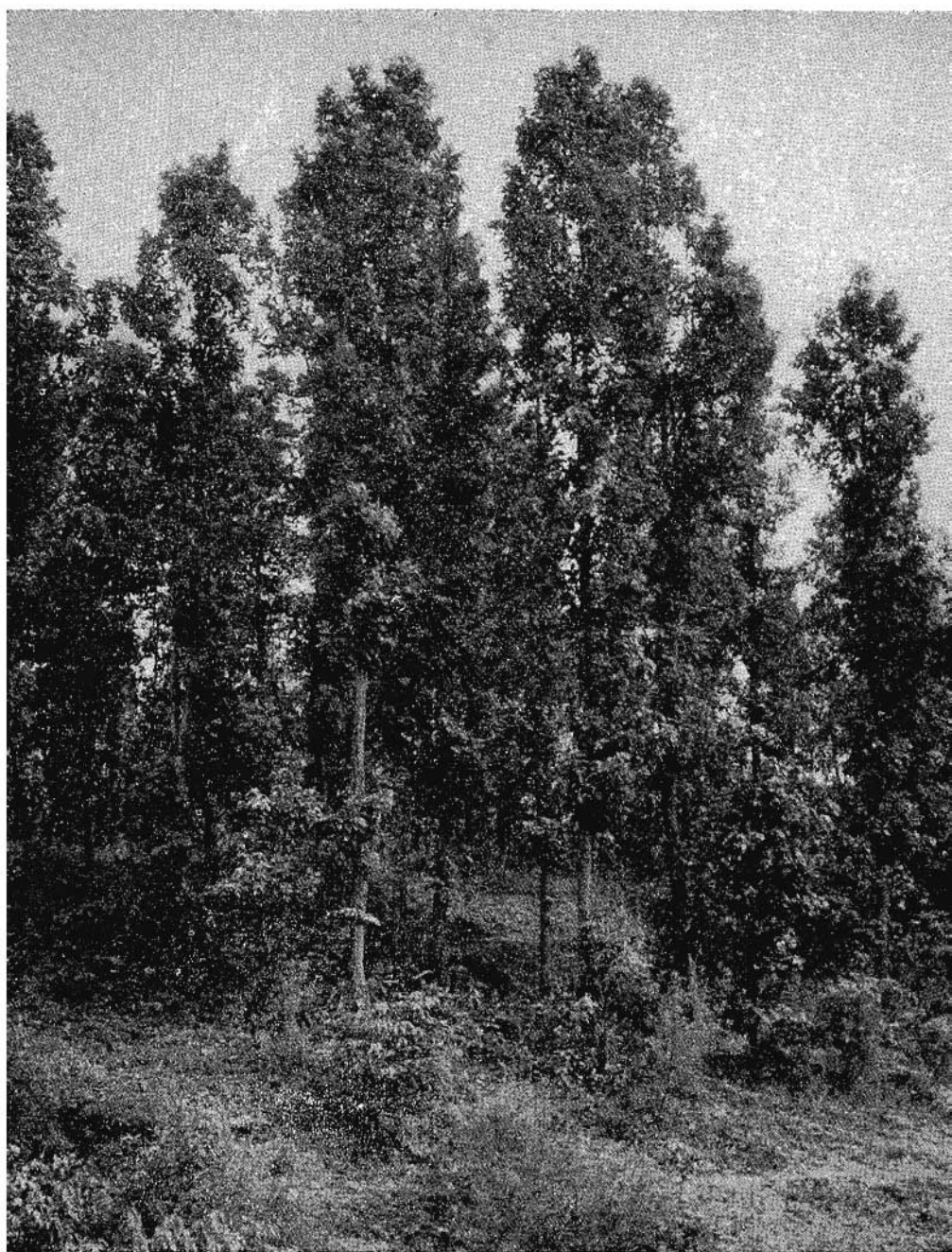


FIG. 9. *Sal* forests in Assam

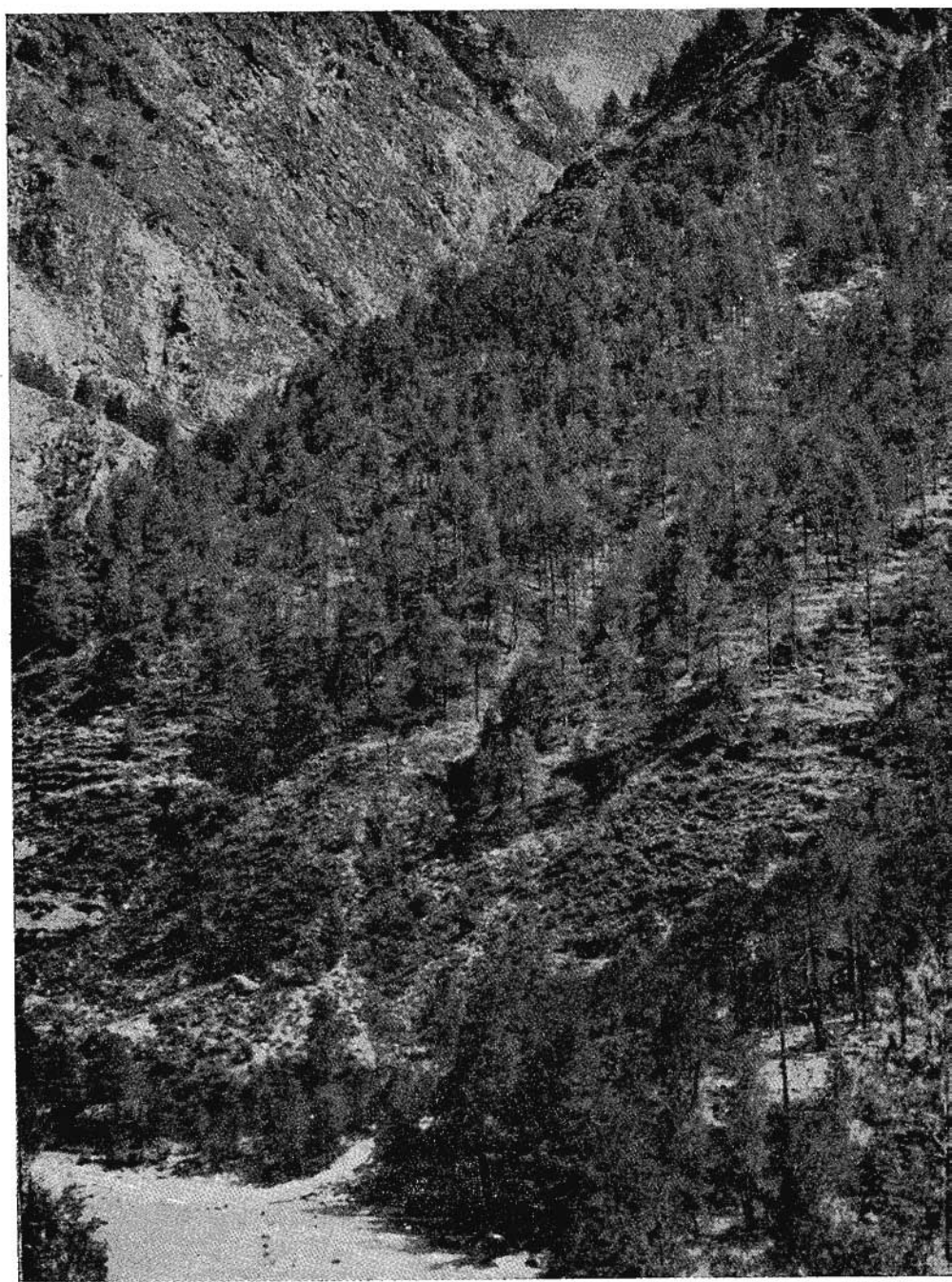


FIG. 10. Chil forests in Western Himalayas

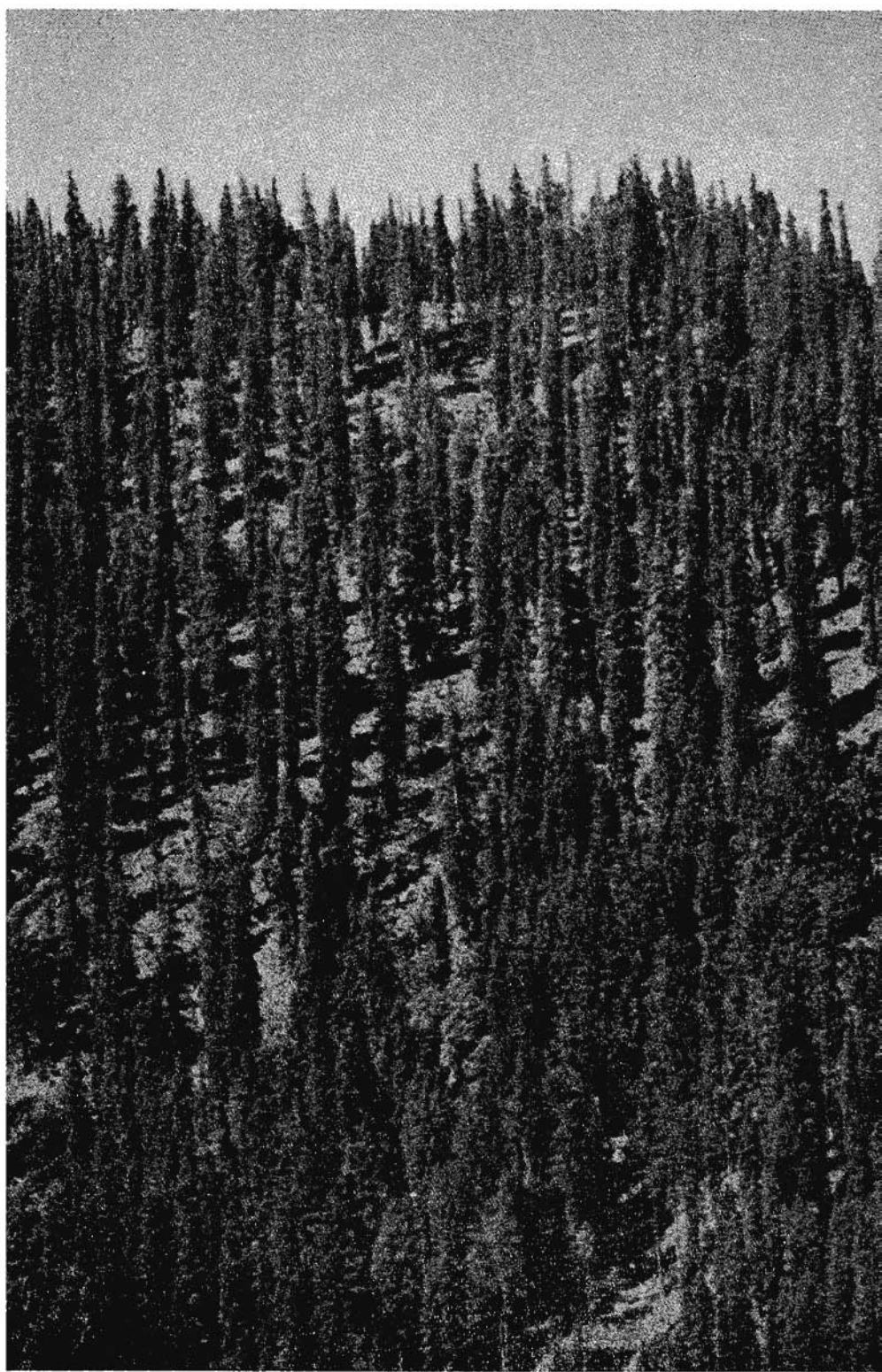


FIG. 11. Silver fir (*Abies pindrow*) forests in Western Himalayas.

North-East Assam. In the north-eastern corner of Assam (rainfall about 80 inches) the flora at about 5,000 ft. includes oaks, maples, pears, magnolias and among the characteristic species are also to be mentioned *Nanglietia*, *Nlichelia*, *Bucklandia popzelanea*, *Alzizs nepalensis*, *Betula alnoides* and *Carpinus viminea*.

Eastern Himalayas. In this are included the regions of Sikkim, Bhutan, the Balipara Frontier Tract, and the outlying Patkai, Barail, Khasi and the Garo ranges. The evergreen type of vegetation found in these areas are distinguishable into the following sub-zones.

(1) Laurel forest (approximately 6,000 to 7,000 ft.), consisting characteristically of *Machilus edulis*, *Beilschmiedia* spp., *Cinnamomum obtusifolium*, *Litsaea* spp., *Michelin cathcartii*, *Magnolia campbellii*, *Engelhardtia spicata*, *Schima zvallichii*, *Pasania spicata*, *Prunus nepalensis*, *Mallotus nepalensis*, *Betula alnoides*, *Acer laevigatum*, *Acer campbellii*, *Eurya acuminata*, *Symplocos theaefolia*, *Castanopsis tribuloides* and species of *Araliaceae*.

(2) Buk-oak forest (approximately 7,000 to 8,000 ft.) consisting of *Quercus lamellosa*, *Acer carrapbellii*, *Castanopsis tribuloides*, *Miclaelia* sp. and many other species of the laurel forest.

(3) High-level oak forest (approximately 8,000 to 9,000 ft.) with *Quercus pachyphylla* intermixed with many of the buk-oak associates.

Nepal said Sikkim. The Temperate forests in these areas are to be seen at 7,000 ft. zone in Nepal, more particularly on its eastern part, and in Sikkim. The oaks of the Central Himalayas are replaced by *Pasania pachyphylla* and *Quercus Lineata* in association with groups of *Tsuga brunoniana* on warmer slopes and of *Abies densa* at high elevations. The chief among other species are: *Acer campbellii*, *Magnolia campbellii*, *Betula utilis*, *Taxus baccata*, *Rhododendron arboreum*, *R. grazzde*, *Brassaiopsis alpina*, *Acer pectinatum*, *Daphne caaznabina*, *Rubus niveus*, and *Berberis aristata*.

Ferns are abundant and mosses cover the stems of the trees. In the under-storey *Rhododendron arboreum* is found.

Oaks and other broadleaved species become less frequent with the diminishing rainfall in the interior. In the zone from 9,000 to 11,000 ft. in the inner hills of northeastern Sikkim, the conifers met with are *Picea spinulosa*, *Pinus excelsa*, *Larix griffithii*, *Juniperus wallichiana* and *Tsuga brunoniana*.

The most conspicuous trees are Magnoliaceae with five species. The other conspicuous trees of this region are oaks, laurels, maples, birches, alders and conifers. The conifers are chiefly confined to a belt of 9,000 ft. to 12,000 ft. elevation. The absence of true pine or cypress in this region is a point worth noticing. Other shrubs are species of *Clematis*, *Berberis*, *Ilex*, *Rosa*, *Rubus*, *Cotoneaster*, *Spiraea*, *Hydrangea*, *Acuba*, *Lonicera*, *Leycesteria*, *Osmanthus*, *Osbeckia*; *Buddleia*, *Taccinunz*, *Viburnum*, *Polygonum*, etc. Beautiful herbaceous plants abound such as anemones, aconites, violets, many species of balsams, and *Potentilla*, *Fragaria* and *Gentiana*, *Campanula*, *Goelogyne*, *Polygonatum*, *Smilacina*, *Lilium*, *Fritillaria*, *Arisaema*, etc. Only two palms inhabit this zone, a scandent rattan, *Plectocomia himalaica* and a fan-palm, *Trachycarpus martiana*. Dwarf bamboos abound, some of them forming impervious thickets infested with leeches and large ticks.

Western Himalayas. In this region is included the Kumaon, Garhwal, Himachal Pradesh, Simla Hills, Kangra, Kulu, and Jammu and Kashmir. The Western Himalayan region to the west of the Sutlej differs from the Eastern in its greater length, higher altitude, cooler and drier climate and far greater breadth of the mountainous masses. Above 4,000 ft., the climate is temperate and humid and forests of chit-pine, *Pinus roxburghii* are commonly found along with those of oaks and rhododendrons. In somewhat dry regions, like Chini in Himachal Pradesh, *Pizzus gerardiana* lends character to the landscape. Other common trees are the Indian horse-chestnut, maple and walnut.

The chit-pine forests extend up to 6,500 ft. and in their upper limit gradually get mixed up with *Quercus incana*. The forest floor, on the dry, south-facing slopes of the Outer Himalayas are unusually open and grassy. On very exposed areas *Euphorbia royaleana* is common.

From 6,000 ft. upwards, *Quercus incana* becomes characteristic, associated with *Rhododendron arboreum* and

Andromeda elliptica, with the straggling *Rosa moschata* covering them. Shrubs like *Ilex gerardiana*, *Spiraea bella*, *Deutzia* sp., *Leycesteria formosa*, *Piptanthus nepalensis*, *Pyrus ursina*, *P. pashia*, *Rosa sericea*, *R. macrophylla*, *Viburnum foetens*, *Berberis*, *Ribes glaciale*, *Lonicera parviflora*, *Rubus lasiocarpus* and *Prunus padus* are common.

From 7,000 to 10,000 ft. altitude, the characteristic trees are *Quercus semecarpifolia*, *Q. dilatata*, *Abies pindrow*, and *Cedrus deodara*. The typical oak forests consist of tall straight trees, laden with the lichen, *Usnea barbata*. The abies are also tall and stately often reaching 200 ft. in height. The principal associates of quercus-abies forests are *Arundinaria* sp. and *Taxus* sp. A few climbers like *Vitis semicordata*, *Clematis montana* and *Hedera nepalensis* are also common. *Cedrus deodara* forms the most stately tree in these forests in the Himalayas. At about 9,000 to 10,000 ft. *Pinus wallichiana*, *Picea amthiana* and *Cupressus torulosa* also occur in some localities. These forests usually grow on moist north-facing slopes, the sunny south-facing slopes being usually barren.

Rhododendron campanulatum with its pink and mauve flowers occurs at about 10,000 ft. Interspersed with rhododendrons are *Taxus baccata*, *Betula utilis* whose much branched dwarf trees with white bark, which peel off in papery rolls, ultimately mark the end of the zone at about 12,000 ft. Clumps of dwarf ringal bamboo, *Arundinaria falcata* are also seen.

VII. ALPINE VEGETATION

The Alpine forests occur throughout the Himalayas above 10,000 ft and up to about 15,000 ft. These forests are generally characterized mainly by low and broad-leaved evergreen trees and conifers, birches, firs, rhododendrons occur in associations as fairly dense mixed forests or low-tangled forests, and in places leading up to dwarf and stunted scrubs of rhododendrons and junipers or even open xerophytic scrubs of *Artemisia*, *Potentilla*, etc.

In the Eastern Himalayas, above 12,000 ft., the prominent families are Compositae, Scrophulariaceae, Primulaceae, Saxifragaceae, Cruciferae; Caryophyllaceae,

Ranunculaceae, Cyperaceae, Gramineae and Fumariaceae. The principal bushes are those of rhododendrons. The largest spread genera are *Pedicularis*, *Primula*, *Corydalis* and *Saxifraga*. The low position of Cyperaceae and Gramineae is notable, remarkably so in contrast to the Western Himalayas. The few trees, scattered at the lower limits of this zone are birches and pines. Junipers, and species of *Ephedra*, *Berberis*, *Lonicera*, *Caragana*, *Rosa*, *Cotoneaster*, *Spiraea* and dwarf willows also occur. The highest recorded flowering plant is a *Festuca* at about 18,300 ft. In drier valleys above 15,000 ft. several species of *Arenaria* occur which form hard hemispheric or globose white cushion-like structures. The most striking plants of this zone are the species of *Meconopsis*, *Rheum nobile*, *Edelweiss*, *Primula* spp., *Tanacetum gossypium*, *Saussurea obaallata*, *Saussurea gossypifera* and the odorous *Rhododendron anthopogon*.

In the Western Himalayas region, the Alpine zone extends from 11,000-12,000 ft. to 15,000 ft. or sometimes even higher. The characteristic trees are the *Betula utilis*, the silver fir, birch, and the junipers. Rhododendrons are far less in numbers than in the Eastern Himalayas. At about 12,000 ft. *Betula utilis* is seen with *Taxus baccata*. Other associated forms are *Rhododendron campanulatum* and *Salix elegans*, and small bushes of *Juniperus recurva*, *Ephedra gerardiana*, *Rhododendron anthopogon* and *R. lepidotum*. Above 12,500 ft., *Primulas* occur commonly, with *Corydalis*, *Gagea* and *Aconitum laeae*. *Meconopsis aculeata*, the pride of the Himalayan Alpine meadows, make their appearances in July and August, with the rare *Nomocharis* which possess purple spotted yellow flowers. Cushion-like growth of *Arenaria festucoides* and some members of Caryophyllaceae and Crassulaceae are striking examples of xerophytic adaptations at high elevations. Gentians are represented by two species and anemones by two, viz., *Anemone polyanthes* and *Anemone rupicola*. About eight species of *Potentillas* with all shades from deepest red to bright yellow, and three species of *Primulas*, light purple to deep are known from these regions. *Cynoglossum uncinatum* is also common. *Androsace lanuginosa* and *Myosotis palpeus* are also found in this zone.

VIII. TIBETAN VEGETATION OF LAHAUL, SPITI AND LADAKH

The flora of Lahaul, Spiti and Ladakh is largely Tibetan and Alpine in character, and may, therefore, be also considered here separately. The only trees seen are the stunted specimens of *Pinus excelsa* and *Betula utilis* on the hill sides. *Juniperus macrocarpa* and *Ephedra vulgaris* are fairly common. Most of the plants have thick hairy leaves and this is true in the case of Saxifragaceae, Crassulaceae and Compositae. The species represented by these families are *Saxifraga imbricata*, *S. stracheyi*, *Sedum asiaticum*, *Sedum ezuerii*, *Leontopodium alpinum*, *Chrysanthemum tibeticum*, *Artemisia stricta*, *A. tournefortiana* and *A. laciniata*. The cushion habit is seen in *Arenaria musciformis* and *Thylacospermum rupifragum* and in *Caragana pygmaea*. Carpet-like habit is to be met with in *Rhododendron anthopogon*, *Salix sclerophylla* and species of *Cotoneaster*.

Another characteristic of Alpine vegetation of this area in the trans-Himalayas is that the plants have brightly coloured flowers. *Aquilegia vulgaris*, *Isopyrum grandiflorum*, *Delphinium cashmirianum*, *D. brunonianum*, *Aconitum heterophyllum* and all the members of Ranunculaceae have bright coloured flowers. *Potentilla bifurca* and *P. multifida*, members of Rosaceae, also have bright flowers. Same is true of *Androsace villosa* and *Gentiana moorcroftiana* belonging to Primulaceae and Gentianaceae, respectively.

IX. MANGROVE VEGETATION

Throughout the tropics, particularly in the littoral regions in estuaries of rivers, in creeks and lagoons of low lying areas, is to be found a peculiar type of vegetation known as the mangrove vegetation or mangrove swamp. Extensive and highly developed mangrove forests are seen in the Malayan Region. In India, mangrove forests are developed in suitable localities along the coastal region, from the Indus Delta in Sind southwards, along West Coast of Peninsular India down to Kerala, and from the Sunderbans southwards along the East Coast of the Peninsula. They are also seen along the coast of the Andamans and the adjacent islands. The mangrove formations extend up rivers sometimes for miles.

The more common families represented in our typical mangrove forests are Rhizophoraceae, Meliaceae, Leguminosae, Combretaceae, Lythraceae, Rubiaceae, Myrsinaceae, Acanthaceae, Verbenaceae, Euphorbiaceae and Palmae.

The following are some of the species met with in the mangrove forests

of India and the Andamans: *Rhizophora mucronata*, *Rhizophora* *coy jugata*, *Ceriops candolleana*, *Ceriops roxburghiana*, *Kandelia candel*, *Bruguiera gymnorrhiza*, *B. eriopetala*, *B. caryophyllioides*, *Xylocarpus granatum*, *Cyrtometra ramiflora*, *Aegialites rotundifolia*, *Xylocarpus molluccensis*, *Lumnitzera racemosa*, *Lumnitzera coccinea*, *Sonneratia apetala*, *Sonneratia alba*, *S. acida*, *Scyphiphora hydrophyllaceae*, *Aegiceras corniculatum*, *Acanthus ilicifolius*, *Avicennia officinalis*, *Excoecaria agallocha*, *Nipa fruticans* and *Phoenix paludosa*.

As regards the distribution of the species in our mangrove forests, along the East and West Coast of India and the Sunderbans and the Andamans, it is seen that while some species such as *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Sonneratia acida* and *Aegiceras corniculatum* are common to all these areas, a few others have rather a restricted distribution in the East Coast of the Peninsular India and in regions east of it. , Among this category may be mentioned *Xylocarpus molluccensis*, *Scyphiphora hydrophyllaceae*, *Nipa fruticans* and *Phoenix paludosa*.

In India one of the most extensively developed mangrove forests is in the Sunderbans in the Ganges Delta. In this forest belt, there are about 50 species of trees which may be conveniently classified under: (1) purely estuarial species, and (2) species common to other parts of India. Among the purely estuarial species are: *Hibiscus tortuosus*, *Thespesia populnea*, *Broronia lanceolata*, *Amoora cuculata*, *Xylocarpus molluccensis*, *Xylocarpus granatum*, *Bouea oppositifolia*, *Erythrina variegata*, *Azadirachta indica*, *Rhizophora conjugata*, *Rhizophora mucronata*, *Ceriops roxburghiana*, *Kandelia candel*, *Bruguiera gymnorrhiza*, *B. parviflora*, *Lumnitzera racemosa*, *Barringtonia racemosa*, *Sonneratia apetala*, *S. acida*, *Aegialites rotundifolia*, *Aegiceras corniculatum*, *Cerbera odollam*, *Avicennia officinalis*, *A. alba*, *Excoecaria agallocha*, *Sapium indicum*,

Casuarina equisetifolia, Jiripa fruticans and Phoenix paludosa. To these may also be added, Hibiscus tiliaceus, Dalbergia spinosa, D. torta, Mucuna gigaztea, Derris sinuata and D. aciginosa, Finlaysonia oboata, Sarcolobus globosus, Acanthus ilicifolius and A. volubilis.

Of species common to inland Bengal may be mentioned: Kleinhovia hospita, Micromelum pubescens, Aegle marmelos, zizyphus jujuba, Lannea coromandelica, Cassia fistula, Pongamia pinnata, Acacia tomentosa, Acacia arabica, Barringtonia acutangula, Ixora paraifora, Morinda bracteata, Diospyros montana, Diospyros malabarica, Cordia myxa, Dolichandrone rheedii, Vitex trifolia, Vitex negundo, Cyclostemon assamicus, Croton oblongifolius, Antidesma ghaesembilla, Tretia nudiflora, Streblus, Trema and Ficus.

The root system of mangroves is highly specialised as special adaptations for their environments, which are often water-logged and poor in aeration. Some species as Rhizophora have a system of aerial stilt roots to support the trees, others as Bruguiera, send up peg-like projections, from their roots, still others as Heritiera, Luminitza and Yandelia produce aerial 'knee roots' and yet others as Aicenia have pneumatophores or breathing roots.

The Rhizophoraceae also exhibit a peculiar phenomenon known as vivipary. By this, as the fruit is still attached to the parent tree, the embryo begins to grow, the hypocotyl protruding, the young seedling hang vertically from the fruit itself.

X. BEACH OR SHORE-LINE VEGETATION

Before concluding, brief mention may also be made of a narrow belt or strip of vegetation seen along the coast, and a little farther from the high tide limits known as the beach forests. In this belt, the trees are partly evergreen and partly deciduous. In places Casuarina equisetifolia is cultivated extensively.

Among the more common species may be mentioned: Mimosa littoralis, Pongamia pinnata, Morinda citrifolia, Erythrina variegata, Calophyllum inophyllum, Terminalia catappa, Barringtonia speciosa, Cordia subcordata, Thespesia populnea, Vigna retusa, Mucuna gigantea, Colubrina asiatica, Calotropis gigantea, Pandanus tectorius, etc.

CHAPTER 7

AGRICULTURAL AND ANIMAL HUSBANDRY REGIONS

THE division of the Indian sub-continent into administrative units called States is based on linguistic, cultural, and other considerations. It has, however, been felt that this division does not facilitate efficient administration of agricultural research, for scattered in different administrative units are areas which have similar climate, soils; crops and domestic animals. There are sometimes similar problems of crop production and animal husbandry in two or more administrative units. For example, wheat or rice or millets are grown in areas falling within different States. The contiguous areas in such States have more or less similar agricultural problems. Jute grows in West Bengal, Assam and Bihar, and problems relating to its cultivation in these States have much in common. Again, plant diseases do not respect State boundaries, and incidence of rust on wheat, for instance, in the Punjab and Uttar Pradesh is more or less a common problem, which can be tackled best on a regional basis. Hence the importance of coordinated schemes, like the one which has resulted in the evolution of rust-resistant varieties of wheat. From the standpoint of animal diseases and nutrition, Assam, Bengal and Bihar have many common problems. The instances given are merely illustrative and can be multiplied.

In view of the similarity of agricultural and animal husbandry problems in administrative units situated within the same region, it is necessary that research stations should be planned on a regional basis rather than on the basis of individual States. This would help avoid unnecessary duplication of work. There are instances of schemes of similar nature having been financed in different States in the same region. In such cases one comprehensive scheme covering all the States concerned would have sufficed. It has been felt, therefore, that programmes of research instead of being limited by State boundaries, should be planned in such a manner as to coffer several States governed by the same soil-climate complex. In other words, programmes of research should recognize only the regional

demarcation of the country and not the political boundaries)f the States.

Broadly speaking, all research problems relating to agriculture and animal husbandry can be classified under three categories: fundamental, regional, and local. In planning research institutions, the requirements under this classification have to be kept in view. It may, however, be mentioned that rigid classification of problems is not possible in all cases, and it is necessary that the entire research organization should function as an organic whole.

AGRICULTURAL REGIONS

In determining agricultural and animal husbandry regions of India the largest number of common factors in respect of rainfall, temperature, altitude, latitude, natural vegetation, soils, crops and stock animals should be taken into consideration. When all these factors are taken into account, what strikes one is their uniformity over wide belts of territory embracing many States. The sub-continent of India can thus be divided into well-marked regions. Within these major agricultural regions, there would be tracts and conditions which would not be representative. These may be designated as special sub-regions. It may be noted that transition from one region to another is gradual, and it is only in the central areas that the differences emerge in full contrast. The following agricultural regions and sub-regions can be defined.

Temperate Himalayan Region. This region includes Assam (Mishmi Hills tracts) Sikkim, West Bengal, Punjab (Kulu and Kangra), U.P., Kumaon and Gharhwal, Darjeeling, Jammu and Kashmir and Himachal Pradesh. Rainfall is heavy- in the outer ranges of the eastern portion. But the northern portion is comparatively dry, though with more winter rainfall and the climate is almost of the -Mediterranean type. There are thick forests of sal in the eastern portion and the forests are the main source of wealth. Mainly a tea and mandarin orange growing area, cultivation of paddy is done in some places. Temperate fruits, particularly, apples, almond, cherries, apricots, peaches, plums occupy a prominent place in the agricultural economy of

the western parts of the region. Other cultivated crops are potato, maize and paddy.

Dry Northern Region. This comprises North Gujarat, Western Madhya Pradesh, Punjab (excluding hilly regions), Rajasthan, Western Uttar Pradesh and Delhi. Annual rainfall in this region is less than 30 inches, and in many places less than eight inches. The soil is mainly alluvial deposited by a large number of rivers in geological times. Wheat, maize, barley, gram, red gram, pea, cotton and sugarcane are the chief crops of this region; also mangoes, citrus and guavas.

Eastern Region. In this region are included Assam (excluding hilly parts), Bihar, Orissa, Eastern Uttar Pradesh, Eastern Madhya Pradesh, West Bengal (excluding hilly parts), Manipur and Tripura. All over this region the annual rainfall is about 60 inches. The main crops are rice, black gram, lentil, jute, sugarcane, bananas, mangoes and tea.

Southern Region. It comprises South Gujarat, Maharashtra (excluding coastal regions), Mysore (excluding coastal regions), Andhra Pradesh (excluding coastal regions) and Madras (excluding coastal regions). The soil of this region is lateritic. Average annual rainfall is about 90 inches. The important crops are rice, millets, jowar, bajra, gram, horse red gram, groundnut, castor, cotton, banana, grapes, mangoes, coffee, tobacco, and tea.

Coastal Region. It comprises the two coastal strips in South India, part bordering on the Eastern and Western Ghats (falling in the States of Andhra Pradesh, Madras, Maharashtra, Mysore and Kerala), Andaman and Nicobar Islands and Laccadive, Minicoy and Amindivi Islands. It is important for rice, cow pea, green gram, coconut, arecanut, rubber, coffee, cashewnut, jackfruit and pineapple, spices like black pepper, cardamom and ginger.

ANIMAL HUSBANDRY REGIONS

On the basis of rainfall, temperature and soil, which influence the quality of livestock, the country can be divided into five animal husbandry regions.

1. Temperate Himalayan Region. It comprises the mountainous areas of Assam, West Bengal, Uttar Pradesh,

Himachal Pradesh, Punjab, and Jammu and Kashmir. In this region the rainfall is heavy and there are snow and frost during winter. The livestock are largely raised on pasture and during winter are commonly moved from the higher altitudes to the valleys and the foot-hills.

Cattle of this area are non-descript and of short stature and comparatively low productivity. Sheep and goats are the principal domestic animals, and wool is the main source of income from livestock. The sheep are good producers of medium-quality fine wool.

2. Dry Northern Region. It comprises the plains in the Punjab, Delhi, Western Uttar Pradesh, Rajasthan and parts of Madhya Pradesh and Gujarat. The rainfall is below 30 inches. The home tracts of most of the important breeds of cattle and buffaloes, e.g., Haryana, Nagore, Malvi, Kankrej, and Gir cattle and Murrah buffaloes, are located in this region. The home tracts of important breeds of sheep yielding carpet type of wool are located in this region. In the arid areas of Rajasthan State, sheep-rearing is an important occupation. Camels are found exclusively in this region. Horses and donkeys are also of comparatively . good quality.

Wheat straw is available in abundance, and cultivation of fodder crops. is commonly practised. Seasonal grazing is also available in many areas. Thus the livestock of this region are comparatively well-fed and on the whole more productive than that of any other region.

3. Wet Eastern Region. It comprises the plains of West Bengal, Bihar, Orissa, Eastern Uttar Pradesh, and parts of Assam and Andhra Pradesh. The rainfall is above 50 inches. Rice is the main cereal crop and its straw is the major source of feed for cattle. There are hardly any fodder crops grown. The cattle and buffaloes of this region are unproductive, non-descript and poorly fed. Buffaloes are frequently used for agricultural operations.

4. Southern Region. It comprises parts of Madhya Pradesh, Maharashtra, Andhra Pradesh, Madras and Mysore States. . Rainfall is generally low. Most of the land is under millets, which also provide fodder for animals. Some of the important draught breeds of cattle, viz., Amrit Mahal, Hallikar, Kangayam and Ongole are reared in this region. There are more

sheep in this region than in any other, but most of these are of hairy type and are valued only for their mutton and skins.

5. Coastal Region. It comprises the coastal strips of the Peninsular India bordering on to the Eastern and Western Ghats including the coastal belts of Maharashtra, Mysore, Kerala and Madras States. This is a heavy rainfall area, the annual precipitation exceeding 200 inches at many places. The livestock in this region are unproductive and subsist mainly on poor-quality paddy straw.

CHAPTER 8

AGRICULTURAL HOLDINGS

THE problem of land reform in India is basically a problem of reorganizing the holdings structure, and thereby creating an agrarian economy with high levels of efficiency and productivity. The average holding in the country is very small. Under all the land systems that prevail, progressive sub-division and fragmentation of holdings continues making the problem of rural development extremely difficult. This process is partly due to the laws of inheritance in vogue, but in a more fundamental sense is a direct result of the growing pressure of population on the land. The area available for cultivation is necessarily limited and, therefore, the immediate task to which agrarian reforms have to address themselves are the reduction of disparities in the ownership of land, checking of fragmentation and consolidation of the existing holdings. However, for this, detailed information about the distribution and size of holdings is indispensable. Until very recently no serious attempt had been made to collect the data on a country-wide scale, and consequently, the question of land reforms could not be tackled satisfactorily.

The Agricultural Labour Enquiry Committee which was conducted in 1950-51 studied the size and dispersion of holdings in 800 villages selected on sample basis. It revealed that taking the country as a whole the cultivators' holdings below one acre were 17 per cent of the total number; those between one and two and a half acres were about 21 per cent; and those between two and a half and five acres were another 21 per cent. About 16 per cent were in the group 10-25 acres, and accounted for 32'5 per cent of the area; holdings above 25 acres were 5'6 per cent of the total number and covered about 34 per cent of the area. Considerable variations were found in the relative size of the holdings in different States. Table on page 72 would give an idea of this as also of the unevenness of distribution.

It will be seen that the average size of holdings was particularly low in the southern and eastern zones, which are mostly rice-growing areas. In Kerala, the average size of the holdings was the lowest, viz., 2.4 acres. In the northern zone, the

average size was 5.3 acres and in the remaining three zones it was a little above 12 .acres. The numerical size, however, hardly conveys a correct idea of the relative position in this regard. Thus, with the exception of the Punjab which is mainly a wheat-growing area and where the land is fertile, the areas having bigger average holdings are s generally of low fertility, unirrigated and poor in all respects.

AGRICULTURE AND ANIMAL HUSBANDRY IN INDIA

AVERAGE SIZE OF HOLDING IN INDIA

States	Cultivators' holdings - Average size (acres)	Concentratio n* ratio
North India	5.3	0.55
Uttar Pradesh	5.3	0.55
East India	4.5	0.56
Bihar	4.1	0.62
Orissa	5.6	0.60
West Bengal	4.7	0 .50
Assam	5.3	0.37
South India	4.5	0.64
Madras	4.5	0.61
Mysore	7.2	0.52
Kerala	2.4	0.66
West India	12.3	0.68
Bombay	9.7	0.56
Central India	12.2	0 .56
Madhya Pradesh	13.9	0.56
North-West India	12.6	0 .55
Rajasthan	16.9	0.56
Punjab	11.8	0.42
Jammu & Kashmir	3 .8	0 .44

*The concentration ratio is a statistical measure of the inequality of the holdings. It is zero when all holdings are of equal size, and one when they are infinitely uneven.

It has also revealed that compared to the overall average of 7.5 acres, the size of holdings of agricultural labour families was only 2.9 acres.

The difficulty felt in the formulation of a correct land policy led to a detailed census of holdings in 1953-54. This census was carried out in 22 States. In ten States, namely, Andhra Pradesh, Bombay, Madhya Pradesh, Madras, Hyderabad, Madhya Bharat, Saurashtra, Ajmer, Bhopal and Kutch it was based on a complete enumeration of all holdings; in seven States, i.e., Punjab, Mysore, Coorg, Delhi, Himachal Pradesh and Vindhya Pradesh, it was restricted to holdings of ten acres and above; in Uttar Pradesh, Bihar, Orissa, Rajasthan and Kerala it was based on a sample survey. In Assam and West Bengal, the State Governments had earlier collected data regarding land holdings, and a special census was, therefore, not considered necessary. In Jammu and Kashmir also, where a ceiling on land ownership had been imposed earlier, the census was not held. In Manipur and Tripura, the census could not be carried out on account of difficulties of terrain and lack of personnel. The data made available by the census relates to the size and distribution of: (a) holdings classified according to area owned, and (b) holdings classified according to area under personal cultivation.

In the eighth round of National Sample Survey during July 1954 to March 1955, an all-India survey of ownership holdings was conducted on a sample basis in 1704 villages covering 12,480 households. The survey revealed that a little over one-fifth i.e., about one and a half crores of households did not own any land. About one-fourth of all rural households had a small parcel of land less than one acre in area. At the upper end, about one-eighth of the households had more than ten acres with a total share of two-thirds of the whole area, accounting for one-fifth of the total area. The estimated average for all households having land was about six acres. Out of a total of 6.5 or 6.6 crores of households, about one lakh of households had

more than 100 acres and only a few thousand more than 250 acres.

CEILING ON AGRICULTURAL HOLDINGS

The First Five Year Plan accepted the principle that there should be an absolute limit to the amount of land which an individual may hold. The data emerging from the census have made it possible for the States to prepare plans for the imposition of such ceilings. During the Second Five Year Plan, all the States were to carry out necessary reforms in this regard.

In determining the level at which the ceiling should apply, there is need for some convenient unit which could be indicated in a general way and later worked out in detail in different areas. In the First Five Year Plan, it was suggested that for this and related purposes, multiples of what may be regarded as a 'family holding' in any given area may be used. A family holding was described as an area equivalent, according to local conditions and the existing conditions of technique, to either a plough unit or a work unit for a family of average size which could yield a certain average income. It is, however, difficult to correlate a family holding to a given level of money income. The balance of convenience, therefore, lies in favour of each State specifying, according to conditions of different regions, classes of soils, irrigation etc., the area of land which may be declared to be a family holding. It has been suggested that the ceiling should be placed at about three times the size of a family holding's size. Exemptions from the ceiling may have to be given in special cases, such as: (i) tea, coffee and rubber plantations, (ii) specialized farms engaged in cattle breeding, dairying, wool, raising, etc., (iii) sugarcane farms operated by sugarcane factories; and (iv) efficiently managed farms which consist of compact blocks and on which heavy investment or permanent structural improvements have been made.

Ceiling on agricultural holdings has two aspects: (i) ceiling on future acquisitions; and (ii) ceiling on existing holdings. Under (i) ceiling has been imposed in the following States: _

1. Andhra Pradesh	Telangana area	12 to 180 acres.
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2. Assam	Plain districts	50 acres.
3. Bombay	Former Bombay area	12 to 48 acres.
	Saurashtra area	60 to 120 acres.
	Marathwada area	12 to 180 acres.
	Vidarbha and Kutch areas	3 family holdings(area to be determined by the Tribunal).
4. Jammu and Kashmir		223/4 acres.
5. Madhya Pradesh	Madhya Bharat area	50 acres.
6. Mysore	Karnataka area	12 to 180 acres.
	Bombay area	12 to 48 acres.
7. Punjab and PEPSU area		30 standard acres.
8. Rajasthan		30 irrigated acres or 90 dry acres.
9. Uttar Pradesh		12 2 acres.
10. West Bengal		25 acres.
11. Delhi		30 standard acres.

In regard to ceiling on existing holdings, legislation has been enacted in the following States:

1. Andhra Pradesh	Telangana area	18 to 270 acres.
2. Assam	Plain districts	50 acres.
3. Bombay	Marathwada area	18 to 270 acres.
	Vidarbha & Kutch areas	6 family holdings.
4. Jammu and Kashmir		24 acres.
5. Mysore	Karnataka area	18 to 270 acres.
6. Punjab	PEPSU area	30 standard acres.
7. West Bengal		25 acres.
8. Himachal Pradesh		30 acres in Chamba district and area assessed at Rs. 125 in other areas.

The implementation of legislation for imposition of ceiling on existing holdings has been completed in Jammu and Kashmir. It is at different stages of implementation in the remaining States.]

CONSOLIDATION OF HOLDINGS

In the First Five Year Plan, it was urged that in all States, programmes for consolidation of holdings should be expanded and pursued with vigour. The advantages of consolidation of holdings are well known. Consolidation saves time and labour, facilitates improvement of land through irrigation as well as dry farming practices, provides an opportunity for replanning individual holdings and the village abadi and providing roads and other amenities. Since the inception of the scheme in various States, an area of 192 lakh acres has been consolidated up to the end of June 1959. Appreciable progress has, however, been made only in a few States. Out of the total area consolidated, Maharashtra accounts for 18 lakh acres, Madhya Pradesh for 33 lakh acres, Punjab for 95 lakh acres and Uttar Pradesh for 301akh acres. In other States, the consolidation schemes are at various stages of implementation. Thus, while there is growing interest in some States in programmes 'of consolidation of holdings, much more needs to be done. In the National Extension and Community Project areas, consolidation of holdings will be undertaken as an item of primary importance in the agricultural programme. It is proposed to intensify the programme of consolidation during the Third Five Year Plan. Legislative provisions for consolidation of holdings have been made in most of the States. With a view to assisting the States to expand their programmes, the scheme has been made eligible for Central assistance.

The Planning Commission has recently completed two studies on methods and problems and suggestions, and recommendations relating to consolidation of holdings. Methods evolved in different parts of the country have been put at one place for the benefit of the States where the work is in progress. The main problems faced in undertaking a programme of consolidation have been listed. While it is expected that each State would have its own problems in launching consolidation

work and its own experience would be useful in dealing with the local situation, an attempt has been made in the above studies to indicate some of the ways by which the time taken and the cost involved in consolidation could be reduced and work made a little less complex.

Provisions for prevention of fragmentation have been enacted in many States. With some variation in detail, the law generally provides that no holding shall be transferred or partitioned in such a way as to leave a plot of land or a holding of a size which it is unprofitable to cultivate. In some States, provisions relate only to the total holding of a cultivator while in others they also regulate the size of each plot in a holding.

CHAPTER 9

IRRIGATION

INDIA is the most extensively irrigated country in the world. Her need for large-scale irrigation has been recognised in spite of the annual rainfall averaging to about 45 inches. While some parts of Rajasthan receive an annual precipitation of less than five inches, the rainfall at Cherrapunji in the Assam Hills approaches about 500 inches. Between these two extremes exists a wide range of conditions. This would explain why in some parts irrigation is indispensable for cultivation, why in others it is essential for proper crop production, and why in certain other parts it is totally unnecessary. The annual variations in the rainfall and the seasonal changes in its distribution add further to the complexity of the situation.

Except for the south-eastern part of the Peninsula, where the rains are the heaviest from December to October, the country generally receives most of the precipitation from the South-West Monsoon. In the winter months the rainfall varies from half inch to two or more inches. But from March to the end of the hot weather and the onset of the South-West Monsoon almost dry conditions prevail.

Under favourable circumstances, the monsoon from Bombay may overlap and reinforce that from Bengal; under unfavourable circumstances the union may be feeble and intermittent. Again, the monsoon may arrive late or may withdraw too soon. It is thus not uncommon for the annual rainfall in many parts of the country to fall to half or even quarter of the normal. The shortage has, therefore, to be made good from other water resources.

In those parts of the country where the average annual rainfall is less than ten inches, cultivation without irrigation is virtually impossible. The position of areas in which it ranges from 10 to 50 inches may be regarded as 'uncertain'. There a deficiency of 25 per cent may cause considerable damage to the crops, and a shortage of 40 per cent may spell scarcity conditions or even famine. That a short-fall of 20 inches in a normal precipitation of 50 inches can lead to famine may appear

surprising, but it should be remembered that areas of this order of rainfall are almost invariably rice-growing regions which cannot withstand any considerable shortage of rains without suffering a heavy crop failure. Similarly, paucity of rain in areas which normally receive an annual precipitation of 25 inches, might lead to the failure of cotton or millet crop. The need for having proper- irrigation facilities in all such areas is, therefore, obvious.

IRRIGATION PROSPECTS

India is divided by nature into two parts. In the North sprawls the alluvial Indo-Gangetic plain; in the South lies the rocky table-land of the Peninsula. The rivers of northern India are snow-fed and flow all the year round, though the supplies in winter are low. The rivers of central and southern India depend entirely on rainfall with the result that in dry weather they sometimes dwindle to a mere trickle. The total annual flow of the river waters in the country is estimated at 1356 million acre feet, of which only about ten per cent. is at present used for irrigation.

The Indus, with its four great tributaries, the Jhelum,- the Chenab, the Ravi and the Sutlej, after rising in the Himalayas, runs like a five-pronged fork through the Punjab State and discharges into the Arabian Sea. The Ganges with its tributary, the Jamuna, issues from the Himalayas a few hundred miles to the east of the Sutlej, and is joined by numerous other Himalayan rivers, notably the Ghagra, Gandak, and Kosi. It finally mingles with the mighty Brahmaputra before entering into the Bay of Bengal. The Ganges differs from the almost completely snow-fed Indus in that its waters are supplemented to a considerable degree by many rivers rising in the uplands. The Aravallis, a rocky range of hills extending north-east through Rajasthan from Mount Abu almost to the confines of Delhi, separate the Indus basin from the Chambal, the most westerly of the southern distributaries of the Ganges which have their origin in a southern boundary roughly demarcated by the Tropic of Cancer.

In the Central Plateau, the Narbada and Tapti rise and flow westwards to join the Arabian Sea north of the Western Ghats, a range of hills which together with the heights of Central

India forms the watershed of several great rivers of Madras and Orissa States which discharge into the Bay of Bengal. Among these rivers, the Cauvery, the Krishna, the Godavari and the Mahanadi have contributed largely to the irrigation of the coastal areas.

PROGRESS OF IRRIGATION

The earliest irrigation attempts were confined mainly to using the flood waters of rivers. Areas flanking the rivers had the benefit of floods. The submerged land was cultivated only after the floods receded. In course of time channels were dug to carry the flood water to longer distances, but these channels soon used to get choked with the silt carried by the water. Side by side, methods of using natural shortage by tapping the sub-soil water were developed. Only shallow wells could be dug and their utility was limited to the efficacy of the lifting appliance.

Wells had been very popular in the northern part of the country. However, the Plateau in the South did not prove very suitable for digging them. But its rolling topography offered good facilities for water storage, and these were exploited by building earthen embankments. In the Himalayan catchments where the valleys, both minor and major, run into deep gorges, no earth dams were possible. Only small works were, therefore, attempted. Rainfall being quite copious and well-distributed, usually small irrigation channels were built.

Sometimes enlightened rulers constructed large irrigation works. The most outstanding example of ancient engineering talent is the grand anicut built across the Cauvery in South India in the second century A.D. This engineering feat was unrivalled in the world. Similarly, the two big tanks in Chingleput district of Madras, said to have been constructed in the eighth and ninth centuries A.D., are monumental. These tanks still irrigate 2,000-4,000 acres every year. Large tanks here also constructed by the rulers of Rajasthan, though they were primarily meant for domestic use. In the North, the Jamuna Canal was constructed in the 14th century.

The British started by undertaking the renovation of the existing works. Some of the outstanding examples of this are the achievements of Dais on the Western Jamuna Canal, of Cautley

on the Eastern Jamuna Canal, and of Cotton on the Cauvery Delta. The success achieved by these pioneers on the reconditioning of old works gave them the confidence to forge ahead with new projects. Dais conceived of the Upper Bari Doab project. Cautley took up the construction of the Ganges Canal, and Cotton decided to build barrages across the Godavari at a point where the river was four miles wide. In spite of these works, the total irrigation in the country till 1860 covered only three million acres.

In the following two decades a number of new projects were completed on the example of the work done in Madras, U.P., and the Punjab. Thereafter the progress became still faster. The first masonry dam was constructed at Periyar in Madras. Bombay followed by constructing storage tanks. New techniques of building masonry weirs on loose and shifting beds were evolved. Sheet piling, employment of cement concrete on a huge scale, and many other technical improvements were introduced.

The irrigation expansion in the country which was progressing apace suffered a setback during the slump which started in 1930. But in spite of the adverse conditions, U.P. found a new use for the Ganges Canal water that had a series of low head falls in its upper reaches. Hydroelectric power was produced from these canal falls, and the electricity generated was transmitted to areas not receiving canal water. As a result of this, 1,500 tubewells that could irrigate 6,000,00 acres were set up. A standard tubewell was 300 feet deep and had an output 15-20 times larger than that of a shallow well.

Irrigation came to have pointed attention after the separation of Burma in 1937 which aggravated the food shortage in the country. Rice imports from Burma were considerably curtailed. The food problem became particularly acute in 1943 when the Bengal Famine broke out.

The Grow More Food Campaign had been started a year earlier, and it had been decided to launch small irrigation schemes throughout the country to overcome the scarcity conditions. The Bengal Famine only underlined the need for immediate action on a national scale. Finances were made available for all-round expansion, and a number of schemes which could be undertaken with the available resources were launched.

The Partition of the country in 1947 and the consequent transfer to Pakistan of large irrigated areas of the Punjab accentuated the food problem considerably. It was realized that the solution of the problem depended largely on the extension of irrigation. New works were undertaken in hurry. A dam was constructed here and a weir there-all under the pressure of circumstances and local interests. Such independent State activities were later replaced by all-India planning on a more comprehensive and better coordinated basis.

By 1950, the need for integrated development was fully accepted. A comprehensive plan was drawn up in accordance with the availability of men and materials and the need for maximum utilization of water resources. Large-scale projects were proposed. These had necessarily to be multipurpose in character. New methods of construction, transport and haulage of material, power generation, and flood control which modern technology has evolved, have made the planning of such projects possible. As many as 19 dams have been taken up for construction. These include a number of large dams like those of Bhakra Nangal, Damodar Valley, Hirakud and Tungabhadra. The storage capacity of all the dams constructed prior to 1947 was only eight million acre feet. The new dams have been designed to store 38 million acre feet of water, i.e., nearly five times as much as the old ones could.

In 1951, the First Five Year Plan was launched. It provided for the construction of storage reservoirs with a capacity of 35.4 million acre feet. With the completion of works provided in the Plan, the storage reservoirs in the country would have a total capacity of 81.4 million acre feet.

The progressive increase in irrigated area which took place between 1850 and 1945 in the country (pre-Partition India) is given below:

1850	..	..	2-3 Million acres
1895	..	..	29 "
1910	..	..	33 "
1915	..	..	40 "
1925	..	..	43 "
1935	..	..	49 "
1945	..	..	49 " "

Hardly six per cent of the water resources had been tapped, and the irrigated area was about one-fifth of the total cultivated acreage.

The Partition left the country with 48.4 million acres of irrigated area-157 million acres served by Government canals, and 327 million acres by private irrigation schemes. By 1951 the irrigated area increased to 51'5 million acres. The achievement under the First Plan amounts to ten million acres on account of minor irrigation works and four million acres on account of major and medium projects. The Second Plan provides for additional irrigation of 21 million acres by 1961. At this rate of expansion, it is hoped that the country will have irrigation facilities for 100 million acres by 1966.

MAJOR IRRIGATION PROJECTS

Ganges Canal. Though the surveys began in 1836, actual work could be started only in 1842. The canal was first opened in 1854. The designed supply of full 6,750 cubic feet of water per second was admitted at the headworks at Hardwar not until the famine of 1861-62.

It is not the headworks of the Ganges Canal that compel admiration; it is the scope of the entire project and the great engineering feat executed in transporting water over the first 20 miles until command was obtained that overbear the mind. The devices employed for crossings are reminiscent of railway practice. The masonry super-passage at Ranipur level crossing at Dhanauri and the design of the Solani aqueduct are particularly outstanding. The canal crosses the Solani by means of a masonry channel, 170 feet wide and 10 feet deep, with roads on each bank.

The Ganges Canal has been able to achieve a maximum annual irrigation of 1 ~73 million acres out of a commanded area of 371 million acres.

Upper Bari Doab Canal. The canal was designed to serve the watershed between the Ravi and the Beas. Its construction was undertaken in 1849 and completed in 1859. As in the case of the Ganges, the Ravi was then considered too

great and too rapid a boulder river to be controlled by a permanent masonry weir constructed on its loose and shifting bed. Further, as on the Ganges Canal (but to a much greater degree), the excessive bed slopes engendered high velocities which led to severe erosion and a retrogression of levels that threatened the stability of the bridges and other masonry works. Measures were taken to check the erosion and the canal was simultaneously enlarged to permit greater supplies being admitted during the monsoon. Construction of permanent headworks consisting of a 3,000 feet long weir -was also undertaken. It was completed in 1885 after a protracted battle with the torrential Ravi. Despite the early setback, the Upper Bari Doab Canal was soon able to convert what was a virtual jungle into a prosperous and cultivated region.

Godavari Delta System. Construction of a weir on the Godavari had been under consideration for a long time, but it was only in 1846, following a succession of famines between 1832 and 1841, that the project was finally sanctioned. The headworks consisted of 21/4 miles of weir, 11/4 miles of embankment and 3 separate canal-head regulators each complete with navigation locks and under-sluices. The magnitude of the work, was quite unprecedented, and was even bigger than that of the weir constructed on the Cauvery in Tanjore district.

Works in Bombay Presidency. Following the example set by Madras, U.P. and the Punjab, the Bombay Presidency also launched a number of irrigation works. The ten small weirs on the Lower Panjhra in Khandesh were taken over, and the precarious supplies in the dry season supplemented by the construction of a new reservoir. This construction paved the way for greater storage works which were subsequently undertaken in the Deccan to impound the flood of monsoon waters in the rivers. Of the other works constructed at this time, the Waghdam tank with an earthen dam nearly 100 feet high is particularly noteworthy.

Krishna Delta System. In 1851, after nearly 50 years of study and examination, a project was sanctioned for the use of the Krishna waters. It was not until the Godavari system gave good promise of success that this project was undertaken. A masonry weir was constructed at a point 60 miles from the mouth of the river. It measured 3,350 feet in length and 15 feet in

height, and was located on a bed of pure shifting sand where the floods used to rise annually by as much as 40 feet. On each flank of the weir were canal-head regulators and under-sluices. One high level canal on the eastern system was navigable, and linked the Krishna with Ellore where a junction was effected with the Godavari navigation canals. The Krishna canals now irrigate over 7,00,000 acres.

Two private irrigation companies were floated about the middle of the 19th century but they proved a failure, and the works started by them, viz., the Orissa Project, the Midnapur Project, and the Sone Project, had to be taken over by Government.. Consequent upon the failure of private irrigation companies, Government adopted a policy of financing productive irrigation works with public loans. The first major projects taken up under this policy were the Sirhind, Lower Ganges, Agra and Mutha Canals.

Sirhind Canal. This canal taps the waters of the Sutlej at Rupar above its junction with the Beas. It is a notable example of the principle that water should be distributed to the best advantage without regard to territorial boundaries. Originally projected to irrigate the erstwhile Patiala State, it was ultimately modelled to serve a much wider area. The construction of almost every canal has invariably brought out valuable lessons. Thus in this case, the reaction noticed from the excessive slopes on the Bari Doab Canal led to the provision of bed gradients so gentle that the canal silted heavily. The remedial measures taken initiated the first study of river control at headworks and of silt exclusion. The Sirhind Canal System, with a discharge of nearly 10,000 cosecs now irrigates two million acres.

Lower flanges Canal. Following the damage caused by the failure of rains in 1866, the Lower Ganges Canal Project was conceived for extending irrigation in the Jamuna-Ganges Doab. The weir was executed on fine sand. Its subsequent partial failure which necessitated reconstruction led for the first time to a critical examination of the problem of checking the insidious flow of water underneath the foundations of weirs in sand.

The most remarkable work on the canal is the magnificent Nadrai aqueduct of 15 arches, each of 60 feet span, which carries the water over the Kali Nadi, a river subject to

extraordinary variations in flood flow. The canal irrigates over one million acres.

Agra Canal. This canal is the first example of the transfer of irrigation water from one river to another. Its supplies are supplemented from the water escaping from the Ganges Canal into the Hindan which is canalized through the Hindan but into the Jamuna. The weir at Okhla picks up this supplement, thus enabling the irrigation of nearly 4,00,000 acres.

Khadakwasla Dam. In 1869, the first great storage work was undertaken on the Mutha river at Khadakwasla, about ten miles from Poona. The dam and the waste weir, which are nearly one mile in length, took nearly ten years to complete. The profile adopted for the dam was decided after an intensive study of high dams in France, Italy and Spain. It was a bold experiment to employ uncoursed rubble masonry in a dam nearly one hundred feet high, but it proved highly successful and became a precedent for employing similar technique in other high dams in India. The reservoir served the dual purpose of providing Poona city and the adjoining cantonments with drinking water and of irrigating the very precarious tract east of Poona.

Betwa Canal. The Betwa Canal in Uttar Pradesh was sanctioned in 1881. It is the first example of a non-productive work deliberately undertaken for its protective value regardless of heavy financial implications. Betwa is a tributary of Jamuna with a maximum discharge of over 8,00,000 cusecs which becomes almost negligible in winter. The storage reservoir was constructed at Paricha, 17 miles from Jhansi. It impounds 2,500 million cubic feet of water and feeds a canal of 700 cusecs.

Periyar Dam. The construction of the dam was started in 1887 and completed in 1895. It is an outstanding example of engineering skill. The Periyar river has its source in the Western Ghats. Its water used to flow to waste in the Arabian Sea. By means of a high dam built in a deep gorge of the river and a tunnel nearly 14 miles long, the water has been diverted through the watershed into the Vaigai river on the eastern slopes, from where it feeds a canal in the Madura district of Madras. The construction of this 200 feet high dam in the narrow gorge of a highly fitful river was a very difficult and complicated job. Its construction has provided protection to nearly 2,00,000 acres against drought.

Irrigation Works in Madhya Pradesh. Prior to 1897, failure of rains in the erstwhile Central Provinces was practically unknown. The dry spell which occurred during 1897-1903 and which caused two famines, led to the construction of a number of large storage works. Of these, the Mahanadi Canal System, designed to protect the Raipur district which had suffered severely during the famines, is of particular importance. The works consist of a masonry weir at Rudri, which directly serves the canal, and a supplementary reservoir impounded an earthen embankment, over 80 feet high and 11/2 miles long, at Maramsilli on a tributary of the Mahanadi. The project is designed to irrigate 3,00,000 acres.

The Waiganga Canal, a similar storage system with its headworks on the river from which it takes its name, irrigates over 90,000 acres. The supplementary storage reservoir has a separate feeder channel linked with the main canal, and thus serves the lower part of the system.

The Tendula Canal, another protective work, is fed from two reservoirs so close to the confluence of the Tendula and Sukha rivers that the intervening ridge permits of their being linked by a conduit. Both the dams are of earth, the maximum height being 110 feet, and the effective storage no less than 9,000 million cubic feet.

Godavari Canals. The Irrigation Commission recommended the construction of Godavari canals, 'for providing water to larger tracts in the districts of Nasik and Ahmednagar. The main storage reservoir, Lake Beale, situated on a tributary of the Godavari, is formed by a masonry dam over 80 feet high and 4,480 feet long, with storage capacity of 8,800 million cubic feet. In favourable years, the canal irrigates over 5,00,000 acres of valuable crops.

Pravara River Works. The 270 feet high masonry dam, constructed at Bhandardara in the Western Ghats is capable of impounding nearly 13,000 cubic feet of water. This storage work protects the Ahmednagar district and irrigates nearly 60,000 acres.

The Nira Right Bank Canal consists of the Lloyd Dam constructed at Bhatgarh on a tributary of the Nira. In the Whiting

Lake, as much as 24,000 million cubic feet of water are impounded.

Sarda Canal. The headworks of the Sarda Canal, which has a discharge of 9,500 cusecs consists of a barrage, under-sluices, head regulator and connected river training works at Bambassa in the boulder region where the Sarda debouches from the foot-hills. The enormous volumes of water that were running to waste in the Sarda river have been harnessed through it for irrigating areas in the Ganges Godra Doab.

Krishnarajsagar Dam. The former Mysore State took up in 1911 the construction of a dam on the Cauvery and completed it in 1932. The height of the dam is 140 feet, and its length including the weir portion measures 8,600 feet. The capacity of the reservoir is 48,335 million cubic feet. Irrigation of nearly one lakh acres has been achieved through it. The dam has been built in masonry, made up of random rubble stone set in surkhi mortar. The mortar for the masonry was specially prepared at the site with natural hydraulic lime and clay.

Mettur Dam. The dam was constructed on the Cauvery in 1932 with three distinct objects in view: improvement of fluctuating supplies to over a million acres of the delta region, extension of irrigation to 3,00,000 more acres, and development of nearly 50,000 k w. of electric power. The main features of the works were a large dam of cement concrete impounding 90,000 million cubic feet of water, and a new canal from the Cauvery. Mettur is now an important industrial centre with cheap power and ample supply of water.

Bhakra-Nangal Project. It comprises of a 740 feet high straight gravity concrete dam on the Sutlej river, situated near Bhakra village. The length of the dam is 1,700 feet. The lake of the reservoir would have ; water-spread of 59.4 square miles and its storage capacity will be 7.4 million acre feet. Eight miles down the Sutlej river near Nangal, a 95-feet high and 1,000 feet long dam has also been constructed. The construction of the Nangal Dam was started in 1946 and completed in 1956. A 40-mile long canal called Nangal¹ Hydel Canal has been constructed between Nangal and Rupar. Two power houses at Ganguwal and Kotla utilise a 100 feet drop at either place. Two sets of 24,000 k w. have been set up at both the power house. The Nangal Hydel Canal is capable of carrying a discharge of

14,00 cusecs. Power generation at Bhakra would be completed with the installation of five units of 90,000 k w. each. Over 650 miles of main canal and 2,200 miles of distributaries and minors have been completed for achieving irrigation of about 3'6 million acres. The main canals in their entire length have been lined in masonry. This has been done with a view to reducing the loss from percolation. Prevention of such losses would not only provide larger irrigation but would also minimize the risk of water-logging and development of salinity. The type of lining adopted for head-reaches has been completed in cement concrete to a thickness of five inches in the bed and six inches on the side slopes. Because of the scarcity of machinery and the heavy cost of concreting, an alternative specification has been used in the lower reaches.. This consists of a double layer of brick type masonry laid in 1: 2: 3: cement: sand: mortar, with 1/2 thickness of manual mortar sandwiched between the tiles..

While the construction of channels has been done mainly by manual labour, the laying of mass concrete in the dam was a completely mechanised operation.

Over five million cubic yards of concrete have to be laid before the dam can be completed. Concrete laying was started some time in November 1955 after carrying out a full-scale excavation of five million cubic yards of rock from the sides and the bed of the Bhakra gorge. Related to the removal of this large quantity of rock was excavation of loose overburden aggregating another five million cubic yards. These operations and procurement of the machinery required for laying concrete took nearly ten years.

Tungabhadra Project. In Bellary district, now in Mysore State, at Hospet across the Tungabhadra river, the construction of a dam was started in 1945. It is a straight gravity type masonry dam, 165 feet high at the deepest portion and 5,942 feet long with a spillway in the centre measuring 2,300 feet. Two saddles on the left bank are closed by an earthen dam 450 feet long, and a composite dam 1,550 feet long. The spillway and the sluice sections are built with granite stones in red cement mortar. The dam is composed of sections, each section being individually stable as a gravity section and free to expand or contract; copper span strips are provided to ensure water tightness at construction joints. The rest of the dam is in lime surkhi mortar.

The reservoir created by the dam would have a water-spread of 145 square miles, and a storage capacity of 1,32,559 million cubic feet. Two canals will take off from the banks; one will be 127 miles long and the other 225 miles. Irrigation of 8'3 lakh acres from the project is envisaged. It went into operation in 1954.

Lower Bhawani Project. In Coimbatore district of Madras across the Bhawani river, construction of a 204 feet dam was started in 1949 and completed in 1956. The dam is 51/2 miles in length, made up of a 1,523 feet masonry dam with 27,339 feet of earth-fill sections. Stone masonry in cement mortar has been used. While the height of the masonry portion is 205 feet above the river bed, the earth dam is 120 feet high. A storage capacity of 0.64 million acre feet has been achieved. On the 125 miles long canal constructed on the right side, irrigation of 2,07,000 acres is forecast.

Hirakud Project. The main dam is about three- miles in length with 11,980 feet of rolled earth-fill and 3,768 feet in two sections of masonry and concrete. Of the latter, 928 feet length is the Power Dam Section tied to the hill on the right flank. There are dykes on the right and left sides to close the gaps in the hills over a total length of about 13 miles. It is thus a 16-mile bund across the mighty Mahanadi, draining at the site 32,200 square miles of wooded and hilly, country with the flood discharge exceeding a million cusecs when at its maximum. The gross storage capacity of the reservoir is 6.60 million acre feet. Over 91 miles of the main canal and branches, and 460 miles of the distributaries and minors have been laid to irrigate 6.72 lakh acres in Sambalpur in Orissa State. Construction was started in 1948. The dam was completed in 1957. The canal system will be completed in 1959.

Mayurakshi Project. Near the border between Bihar and West Bengal across the Mayurakshi river, the construction of a masonry dam, 155 feet high, was started in 1946 and completed in 1956. Twenty miles down the dam, a 1,013 feet long barrage has been completed at Tilpara. Two canals, each 75 miles long, take off from either side of the barrage. The total length of canal system is about 850 miles. The Mayurakshi Scheme is capable of irrigating annually over seven lakh acres in West Bengal and about 25,000 acres in Bihar.

Damodar Valley Project. On the Damodar river and its tributaries, four dams have been constructed at Tilaiya, Konar, Maithon and Panchet. These dams are meant primarily for flood control, but they provide benefits, of power generation and irrigation as well. Through the construction of a barrage at Durgapur, some 10,26,000 acres can be irrigated as against 1,85,000 acres that were being irrigated in the past from the Damodar. The Tilaiya Dam is 99 feet above the river bed, and is of straight gravity type. It has been completed in concrete and has a storage capacity of 3,20,000 acre feet. It has two generating units of 2,000 k w. each; provision has also been made for installing a third unit. Its construction was started in January, 1950 and was completed in December, 1952.

The Konar Dam has been completed across the Konar river. It is 160 feet high, and has storage capacity of 273,000 acre feet. The dam was completed in 1954. It is capable of generating 40,000 k w. of electricity:

The Maithon Dam has been completed across the Barakar tributary of Damodar. Unlike the concrete dams at Tilaiya and Konar, the Maithon Dam is of the rolled earth type with a concrete spillway. Its height ranges from 164 to 182 feet. The storage capacity of the reservoir is 1 -2 million acre feet. Though designed primarily for flood control, it also possesses power generation capacity of 60,000 k w. Its construction was started in 1951 and completed in ,1957.

The fourth dam of the Damodar Valley Project was started in 1952 in Dhanbad district of Bihar State, across the Damodar river. Its construction should have been completed in 1958. With a height of 135-157 feet, its reservoir has a storage capacity of 13,65,000 acre feet. The installed power generation capacity is 40,000 k w.

Kakrapar Project. At Kakrapar, some 50 miles east of Surat in Gujarat, a weir has been constructed , across the Tapi river. The height of the weir is about 60 feet above the foundation. Construction of the weir was started in 1949 and completed in 1955. Two canals take off from the banks. The right bank canal system was a total length of 340 miles, and the left bank canal system of over 500 miles. Construction of the canal systems was completed in 1959. The Project will irrigate over 6-5 lakh acres.

Nagarjunasagar Project. . Construction was started in 1956 on a straight gravity type dam in Nalgonda district of Andhra Pradesh across the Krishna river. It would be 300 feet high, and would create a reservoir with a water-spread of 7366 square miles. The storage capacity of the reservoir will be 5-44 million acre feet. Irrigation canals would take off from both the banks; the right bank canal will be 135 miles long and the left bank canal 108 miles. The construction is scheduled to be completed in 1963-64. Nearly 21 lakh acres of inland .Andhra Pradesh will be irrigated from the water stored at the reservoir.

Gandhisagar Dam. About five miles downstream the Chaurasi-garh Fort in Madhya Pradesh, a 212 feet high dam is under construction across the Chambal river. When completed in 1959, it would store 5.73 million acre feet of water. The reservoir will have a water-spread of over 250 square miles. At the dam site, four generating units of 23,000 k w. each would be installed. Lower down the Chambal river near Kotah city in Rajasthan, a barrage is being constructed, which will be 120 feet high above the foundation. Nearly 230 miles of canals would be constructed from the right bank, and two branches, each 40 miles long, would take off from the left bank. The water stored at the dam site would be diverted at the barrage into the two canal systems for the irrigation of 11 lakh acres. The project is scheduled to be completed in 1962.

Koyna Project. Across Koyna, a tributary of the Krishna, at Deshmukwadi in the North Satara district of Maharashtra, construction of a 200-feet high dam was started in 1954. The reservoir would have a storage capacity of 36,045 million cubic feet, with a water-spread of 21 square miles. When completed in 1961; it will have a power generation capacity of 2,40,000 k w.

Rihand Project. Construction of a gravity type dam was started in 1956, near Pipri village in Mirzapur district of U.P. The dam will be 271 feet high and will create a reservoir with a storage capacity of 8-6 million acre feet and a waterspread of 180 square miles. When completed in 1961-62, five generating units of 50,000 k w. each would provide electric power to the eastern parts of U:P. The water stored at the reservoir will also make available increased steady supplies on the Sone for use in extending irrigation on the existing Sone Canal System of Bihar.

MINOR IRRIGATION SCHEMES.

One-third of the total irrigated area in the country depends on ground water supplies. Sinking of wells is the most popular way of exploiting this resource. The water supply in the existing wells in the alluvium tracts has been improved by boring tubes into the sub-soil. Where the wells have a rocky bottom, special equipment has been used for digging to deeper depths, so that additional water supplies might be had from the fissures so exposed. The excavated depth also provides larger storage space.

In open type wells, water supplies from relatively shallow depths are tapped. For exploiting the deeper resources, tubewells have been constructed, both on private and Government initiative. Wide diameter holes of 30-35 inches can now be drilled, and the mechanical rigs are capable of penetrating into considerable depths. It has thus been possible to construct tubewells with plentiful discharges, even at places where the sand layers are situated considerably below the ground. Techniques of developing the sand layers have also been evolved, so that a high percentage of water contained in these can be pumped out. Satisfactory designs of tubewells have been evolved that can yield sustained discharge for about 20 years. Construction of tubewells has progressed apace and irrigation of over 2-5 million acres has become possible from nearly 8,000 tubewells.

Irrigation from ground water depends basically on having satisfactory water lifting appliances. Financial assistance is, therefore, being provided for the purchase and installation of Persian wheels and pumping sets on individually owned water sources. Cooperative effort on lift irrigation is also in evidence in Andhra Pradesh and Maharashtra. Government is giving financial help to promote such cooperative endeavours.

Besides the use of ground water, small-scale storage of rainwater has been attempted in the central and southern parts of the country. Such storage has been helpful in tiding over seasonal deficiencies of rainfall. Storage tanks are of particular utility in tracts where cultivation is carried on in small scattered patches. Construction of long lengths of channels from any major storage work would not only be difficult but would also involve a

prohibitive cost. It is because of this reason that an increasing number of irrigation tanks is being constructed in the upland areas. Minor irrigation works have been particularly popular in hilly areas, especially in Himalayas where small water channels have been taken out of streams for irrigating scattered fields.

A coordinated scheme for the utilisation of surface and sub-surface water resources is now being worked out. In normal years, the stored water in a tank is used for direct irrigation. Continued water storage, recharges the sub-surface ground water. The replenished ground water can be pumped for irrigation in a year of deficient rainfall when the surface storage of water does not suffice for irrigation.

Rajasthan Canal. Irrigation is projected for over five million acres of virgin land in Rajasthan. For this purpose a large canal will be taken off the Harike Barrage. This canal will pass the first 110 miles of its length through Punjab. Thereafter it is designed to have over 500 miles of water channels in Rajasthan. The discharge capacity of the canal at the head would be 18,500 cusecs and will look almost like a river. It is expected that this canal will have an irrigation capability of 1.68 million acres out of a gross command of 5.1 million acres.

Parambikulam Project. Madras has so much progressed with the exploitation of surface water on their east-flowing rivers that they are now planning diversion of water from the west-flowing rivers that pass through Kerala before their out-fall into Arabian Sea. One such proposal has taken shape and is called Parambikulam Project. Basic idea is to construct structures across the west-flowing river and thereby divert supplies through tunnels to the area situated in Madras State. Upon the completion of seven reservoirs and 9.5 miles of tunnelling, irrigation facility will be reached to 2-5 lakh acres and also 95,000 k w. of electric power will be generated.

Tackling Water-Logging in Punjab. Nearly three million acres presently irrigated land in Punjab has got high water-table because of which satisfactory cultivation cannot be undertaken. To lower the water-table surface drains are being constructed. Also Pilot Schemes are in hand for testing the efficacy of shallow tubewells in relieving the water congestion. A coordinated programme has been worked out in Punjab for lowering the

water-table and also improving such lands where salinity and alkalinity has developed consequent to rise in water-table.

Construction of Drainage. On all new projects that are undertaken for irrigation it has been emphasised that simultaneous to the construction of irrigation channels, drainages must necessarily be completed. Special care is being taken in this regard particularly in tracts where the soil texture is rather firm and the out-fall conditions for the surface water are not very satisfactory.

Importance of Field Channels. The experience on many completed irrigation projects has brought out the need for timely construction of field channels that can convey the irrigation water to small groups of fields measuring not more than 25 acres. In absence of field channels the irrigation area does not increase as fast as originally anticipated. In the interest of accelerated food production, construction of field channels is being increasingly insisted upon the local organizations like Panchayats etc. Where Panchayats are unable to complete the field channels, a Works Programme is undertaken and the cost incurred on construction of field channels is recovered from the beneficiaries in easy instalments.

Second Groundwater Exploration Project. Upon the completion of the First Groundwater Exploration Project, where 16 tracts covering most of the inland river valleys and coastal areas were investigated, a second project has now been initiated which would aim at finding out the groundwater possibilities of tracts that were not so outstandingly groundwater worthy as to be included in the First Project. The First Project aimed at completing successful tubewells with discharges of 25,000 gallons and above. The Second Project will tackle areas where the likelihood of even smaller discharge is indicated.

IRRIGATION RESEARCH

The responsibility of irrigation engineers extends far beyond the construction of weirs, bridges and dams. It also embraces effective distribution of water supplies to the farmers' fields and their proper utilization for crop production. Over-application of water in some parts of the . Punjab and Maharashtra has resulted in appreciable rise of the water-table

which has brought to the soil surface salts which are harmful to crop growths. Steps have been taken by these two States to construct drainage channels that can promptly dispose of the irrigation water after it has seeped through the root zone. Heavy water seepage from irrigation channels is also being checked by lining the channel surface with impervious material. The lining work done over long lengths of the Bhakra canals is an outstanding example of this.

Regulated application of irrigation to the fields located in waterlogged areas is also proposed by replacing surface-water irrigation from the canals with tubewell water. Tubewells are expected to lower the water-table, and also to supplement the water supplies in the canals, which would help in extending irrigation to fresh areas.

Eleven irrigation research stations are functioning in the country, and they carry out experiments on various problems relating to the design, execution and operation of irrigation works. The possibilities of extending ground water irrigation are being investigated by the Exploratory Tubewells Organization of the Ministry of Food and Agriculture. Extensive deep drilling is being carried out in some 16 areas. Seven areas have already been explored, and the work in the remaining would be completed before March 1959.

Investigations have been undertaken to determine the economics of Sprinkler Irrigation. The Indian Council of Agricultural Research is financing these investigations in Himachal Pradesh and the Punjab. Sprinkler Irrigation is likely to be useful in hilly terrains where field preparation for water reception is both difficult and costly. It also holds out good prospects of irrigating areas which possess relatively small water resources.

The Indian Council of Agricultural Research had sponsored in the past a number of schemes for studies on the water requirements of crops. The most important of these were: (a) The Water Requirement Scheme, Lyallpur, (b) The Scheme on Manurial and Water Requirements of Rice Crop in Sind, and (c) The Scheme on Water Requirements of Crops other than Sugarcane in Bombay. The Punjab scheme was started in 1940 and the Sind scheme in 1945. Both these had been sanctioned up to 1949, but they had to be discontinued in 1947 due to the

partition of the country. In addition, the water requirement studies on different crops were also undertaken in connection with other projects, such as Dry Farming Schemes, Sugarcane Scheme at Padegaon (Bombay), etc. Some of the important results achieved are briefly given below.

Wheat. Howard and Howard found out (Pusa Bulletin No. 11 E) that for irrigating wheat, the Quetta cultivators used 30-40 per cent more water than what was required, and that generally led to decrease in yield by about 26 per cent. One or two irrigations were found to be the optimum requirements there. Addition of farmyard manure did not make any difference in their water requirements.

Rice. Studies in Bihar have proved that manuring lowers the water requirement of rice. Pot-culture experiments in Bengal on the water requirements of the rice plant have shown that application of excessive water in the early stages of the growth of aus paddy is detrimental to tillering, and that frequent irrigation at the flowering stage is beneficial. This showed that water-logging of the soil at the early stages of growth should be avoided as far as possible. In Sind, the study of water requirements indicated that transplanting of paddy near about the middle of July was superior to that done during mid-May, mid June and mid-August.

Sugarcane. The irrigation experiments at Shahjehanpur in Uttar Pradesh have shown that in relation to yield, the frequency of irrigation is more important than the depth of water at each irrigation. It was also found that 80,000 gallons per acre per irrigation gave better results than either 60,000 or one lakh gallons. The physiological studies have shown that the critical period in the life of sugarcane crop, with regard to water requirements, extends from the middle of May to the end of June. Under conditions obtaining in Maharashtra, it was found that 95 inches of water per acre inclusive of rainfall, over a period of 12 months would be the minimum water requirement. Increase in the application of nitrogenous manure tended to delay the flowering and maturing of sugarcane, but this could be countered by giving irrigation in greater quantities. It was also found that the water requirement of the crop is not the same throughout all the stages of the plant life. It is highest at the vegetative and flowering stages, and lowest at the maturity stage. It is also found to be

greatly influenced by climatic factors like temperature and humidity.

Recently, the Indian Council of Agricultural Research has launched a scheme of model agronomic experiments. These experiments are meant for carrying out tests on irrigation-cum-manuring requirements of different crops.

SECTION II

CROPS

CHAPTER 10

RICE

RICE (*Oryza sativa*, L.) is probably one of the oldest cultivated cereals in the world. It originated in South-East Asia possibly in India from where it spread through Java and China to other Eastern countries and by agency of Arabs to Middle-East and Europe. It has been cultivated in India since ancient times which fact is supported by archaeological evidence and by many references made to rice in ancient Hindu scriptures and literature. Carbonised paddy grains were found in the

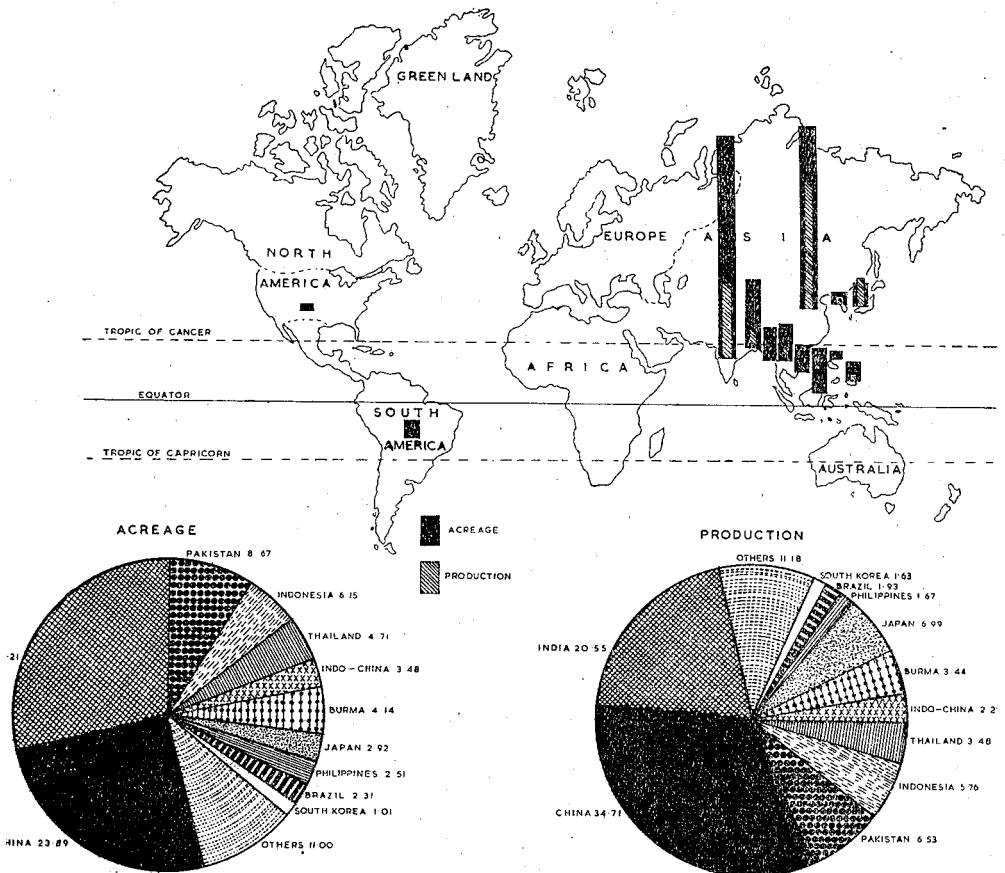


FIG. 12. World rice acreage (million acres) and production (million tons)

excavations at Hasthinapura at a site dated between 1,000-750 B.C. The traditional use of rice in the religious ceremonies of the Hindus associated with birth, marriage and death is a testimony to its great antiquity as also to the intimate place it has in the life of the people.

Rice is the staple food of more than half the population of the world. Though principally a tropical crop, requiring high temperature and humidity for its growth, its cultivation extends from 40° S to 45° N. It occupies about 108 million hectare (266 million acres) and the average annual production is -about 130 million metric tons of clean rice. It is predominantly an Asian crop, 92-78 per cent of the rice being produced and consumed in South Asian countries, extending from Indo-Pakistan Sub-continent to Japan.

The distribution, production and average yield in the principal rice-growing countries are given below:

ACREAGE, PRODUCTION AND YIELD OF RICE IN THE PRINCIPAL RICE-GROWING COUNTRIES

Average of 1954-59)

Country	Area in million hectare	Production in million metric tons	Yield of clean rice in kgln./hec.
India	31.68 (29.21)	26.98 (20.55)	852
China	25.90 (23.89)	45.56 (34.71)	1759
Pakistan	9.40 (8.67)	8.57 (6.53)	911
Indonesia	6.67 (6.15)	7.56 (5.76)	1133
Thailand	5.11 (4.71)	4.56 (3.48)	893
Indo-China	3.78 (3.48)	2.93 (2.23)	776
Burma	4.49 (4.14)	4.52 (3.44)	1006
Japan.	3.16 (2.92)	9.17 (6.99)	2563
Philippines	2.72 (2.51)	2.19 (1.67)	607
Brazil	2.51 (2.31)	2.54 (1.93)	1014
S. Korea	1.10 (1.01)	2.13 (1.63)	1938

U.S.A.	0.70 (0.65)	1.55 (1.18)	2208 ,
Taiwan	0.77 (0.71)	1.57 (1.20)	2038
Malaya	0.36 (0.33)	0.49 (0.37)	1354
Egypt	0.26 (0.24)	0.77 (0.59)	2935
Italy	0.15 (0.14)	0.50 (0.38)	3324
Spain	0.06 (0.06)	0.25 (0.19)	3923
Others	9.62 (8.87)	9.41 (7.17)	978
Total	108.44 (100)	131.25 (100)	..

Figures in the bracket indicate percentage

In spite of the large acreage under rice in Asia, most of the countries of the Continent are deficient in rice. While Burma, Indo-China and Thailand have an exportable surplus, and China, Indonesia and Taiwan are self-sufficient in their rice requirements, the rest of the countries are deficient and have to import rice to feed their people.

India is the largest rice-growing country in the world, cultivating about 31-6 million hectares (78283 million acres) and the production is about 26976 million metric tons of clean rice which is second only to China. Rice is the most important crop of the country, covering more than 15 per cent of the gross cultivated areas, about 30 per cent of the total area under all foodgrains (cereals and pulses), and 36 per cent of the total area under all cereals. The crop is grown practically in all the States in the country, but its cultivation is mostly concentrated in the river valleys, deltas and low-lying coastal areas of north-eastern and southern India in the States of Andhra Pradesh, Assam, Bihar, Maharashtra, Kerala, Madhya Pradesh, Madras, Mysore, Orissa, Uttar Pradesh and West Bengal which together account for about 96.76 per cent of the country's rice production. The average acreage, production and yield in the different States are given below:

ACREAGE, PRODUCTION AND YIELD OF RICE INDIFFERENT STATES IN INDIA

(Average of 1954-59)

State	Area in million hectares	Production in million metric tons	Average yield of rice in kgm. per hectare
Bihar	5. 011 (15 .817)	3. 099 (11.489)	618
West Bengal	4 .168 (13 .1561)	4.185 (15.515)	1004
Madhya Pradesh	3.878 (12. 240)	2. 805 (10.398)	722
Orissa.	3.863 (12. 195)	2.070 (7 .670)	535
Uttar Pradesh	3. 833 (12. 098)	2 .471 (9.161)	644
Andhra Pradesh	2.751 (8.684)	3.289 (12.193)	1195
Madras.	2.215 (6.993)	3 .014 (11.70)	1360
Assam	1.729 (5.457)	1. 682 (6.235)	972
Bombay .	1. 660 (5.239)	1 .521 (5.638)	916
Mysore	0.911 (2.876)	1 .069 (3.964)	1172
Kerala .	0.777 (2.451)	0. 898 (3.328)	1156
Punjab ..	0.300 (0.947)	0.270 (1.003)	900
Jammu & Kashmir	0.183 (0.576)	0.214 (0.796)	1174
Tripura .	0.160 (0.506)	0 .139 (0.514)	868
Manipur	0.118 (0.373)	0. 133 (.0. 495)	1126
Others	0.1238(0.3927)	0 .116 (0.431)	
All India Total .	31.6808(100.0 0)	26.976 (100 .00)	

Figures in the brackets indicate the All-India percentage

India's annual requirement of rice exceeds its production and the deficit is met.by imports. Efforts are being made to

increase the production by providing an assured supply of water and adopting intensive methods of cultivation.

CULTIVATION

Rice cultivation in India extends from 8°-35° N latitude and the crop is grown under widely varying conditions of altitude, rainfall, soil and climate. There are rices grown at sea level in the river' deltas, in areas even below the sea level with protection embankments as in parts of Kerala State, in 15-20 feet of water as the deep water rices in the States of Assam and West Bengal and at the altitudes of 3,000 to 5,000 feet and even more as in Kashmir and the slopes of the Himalayas.

Rice is a semi-aquatic plant, requiring an abundant supply of water for. growth and it thrives best under conditions of high temperature and humidity. The bulk of rice crop in the country is dependent on the rainfall received from the South-West Monsoons and only about 20 per cent of rice area has irrigation facilities. Its distribution mostly follows the rainfall line. Where the annual rainfall exceeds 80", rice is predominant and is purely rain-fed crop. In areas up to 30°-60" of rainfall, rice is an important crop and in areas receiving under 30" of rainfall, the crop is cultivated with the help of irrigation. With regard to soils, though the crop does best in the heavy loams it is grown on diversity of soil conditions, ranging from pH 4.0 to pH 8.0.

Rice-growing seasons vary in different parts of India, depending on the rainfall and other local climatic conditions. However, in greater part of India, the rice crop can be broadly classified in three groups, named according to the season of harvest of the crop. The most important is the aman or winter crop accounting for about 90 per cent of the total; the aus or autumn crop accounts for less than ten per cent, and the boro or summer crop accounts for less than even one per cent. The sowing and harvesting seasons of three crops are as follows

Crop	Sowing	Harvesting
aus or autumn	April June	August-November
aman or winter	June-August	October-January
boro or summer	November January	March-April

The aus or autumn crop comprises mostly 'upland' rices, and varieties of 90-110 days duration are used. The aman or winter crop is grown in low lands and long duration varieties of 140 to 160 days are grown, while for the boro or summer crop, short duration varieties are used.

Cultural and Manorial Practices. Rice cultivation practices vary considerably from place to place according to soil types, rainfall, etc. Therefore, experiments to determine the best time of sowing, optimum seed rate, spacing and age of seedling have been conducted at various experimental stations. It has been found that planting early in the season during the month of July is conducive to higher yields. Spacing and rate of planting depend on the variety, type of soil and time of planting. For early-maturing varieties, a spacing of about 6" X 6" is found to be the best and for medium- and long-duration varieties, a wider spacing of 10" x 6" to 9" X 9" is desirable. Too wide a spacing affects yields adversely owing to the reduction in plant population and consequent reduction in the total number of ears per unit area. Experimental results from all over the country indicate definite superiority of transplanting over broadcast sowing, the increase in yield from the former being 15 to 30 per cent. Besides, there is economy in seed. For transplanting, only 20 to 25 lb. of seed per acre is required which is about one third of what is used in broadcast. The expenditure on weeding is also much less.

Comprehensive investigations in progress in the country to determine the optimum dose of important nutrients, comparative efficiency of different manures and fertilizers and the optimum time and mode of fertilizer application, indicate that on equal nitrogen basis, green manure gives response, similar to ammonium sulphate. Of the inorganic nitrogenous fertilizers tested, sulphate of ammonia has proved to be the most effective. The available data indicate that the ammonical forms of nitrogen are more efficient than the nitrate forms. Experiments conducted at the Central Rice Research Institute, Cuttack and other places with graded doses of ammonium sulphate up to 120 lb. N show that substantial increase in yield is obtained with 20 to 40 lb. of N per acre which is the optimum dose. The response is higher at lower levels and the application beyond 40 lb. N per acre gives no appreciable increase in yield.

Investigations on placement of ammonium sulphate in waterlogged 'rice show that deep placement of fertilizer in sub-surface zone of the soil at the time of puddling or post-planting stage gives response of 14 to 18 lb. of paddy for every pound of N, as compared to 8 to 9 lb. of paddy for every lb. of N in surface application. Fractional application of ammonium sulphate in three splits viz., at planting, one month after planting and two to three weeks before flowering, to supply 40 lb. of N per acre, is found to be more efficient than entire quantity applied in one dose: The time of split dressing of fertilizer coincides with the vegetative growth phase in the early stage and the flowering initiation phase at the later stage when the plant is capable of making better use of fertilizer.

There is definite evidence that incorporation of green matter in paddy soils improves the yield of rice because under the moisture conditions prevailing in rice fields, green matter gets easily decomposed and makes nitrogen available immediately on application. Green manure crop, grown in situ and buried in the soil at puddling or green matter brought from outside and incorporated in the soil, gives similar yield response. For rice areas, quick-growing green manure crops like dhaincha, *Sesbania sericea*, *Sesbania speciosa*, *Sesbania macrocarpa* are found promising. *Gliricidia maculata*, a perennial shrub, can be planted on farm road sides and channel bunds and nearly 30 to 40 lb. of green matter per plant can be obtained every year for green manuring purposes.

Rice responds to the application of phosphatic manures in certain areas. The application of 150 lb. of superphosphate or bonemeal is recommended for the rice soil of Madhya Pradesh and Andhra Pradesh, while for the other tracts 50 lb. of superphosphate or bonemeal are recommended. It is a good practice to apply superphosphate to the previous green manure crop.

Investigations have been carried out to determine the role of blue-green algae in rice nutrition and their effect on the fertility of the soil. The results indicate that fixation of nitrogen is increased by the activity of blue-green algae.

IMPROVED STRAINS

A large number of improved strains of rice (445), suitable for various soil and climatic conditions has been evolved by the State Departments of Agriculture. Some of the common improved strains recommended for different parts of the country are given below. A fuller list can be had from the State Department of Agriculture.

A LIST OF THE IMPROVED STRAINS OF RICE

ANDHRA PRADESH

Abi					Tabi	
	GEB.	24	H.R.	35	MTU.	9
	SLO.	13	H.R.	59	MTU.	15
	SLO.	15	MTU.	15	CH.	45
	R.D.R.	4	MTU.	19	R.D.R.	7
	R.D.R.	7			H.R.	19

ASSAM

Aus or Ahu	Asra or Bao	Sail	Boro
Koimurali	.Negheri	Sroarnasail	Boro I
Kasalath	Panikekoa	Kerrsail	Boro II
Basumati	Sailbadal	Prasadbhog	
Rangaduria		Laudunira	

BIHAR

Aus or Bhadai		Kharif		Summer
	Katika	Aghany		
CH. 1007	B.R.34	BK. 36 °	Sona	
CH. 1039		BK. 88	Sathika	
BR. 21		BK. 115	BR. 19	
BR. 24		BK. 141		
		T. 498-2A		

KERALA

First crop	Second crop	Third crop
P'TB. 10	UR. 19	PTB. 10

PTB. 32

PTB. 12

MADHYA PRADESH

Kharif

Luchai
Sultugurmalia

Chhalri
K. 116, K. 22

Chiuoor

MADRAS

Kar	Samba	Thaladi	Navarai
Early Late			
CO. 13 GEB. 24	CO. 19	CO. 2	C0. 13
ADT. 3	CO. 25	ASD. 5	CO. 18
ADT. 20	GEB. 24	ADT. 8	ADT. 18
ASD. 1	ASD. 5		TKM. 6
TKM. 6			

MAHARASHTRA

Kharif

Sukhael-20 , Kamod-118 Krishuasal	Firasal Yelikar4-4 EX 70
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MYSORE

Kharif .	Rabi
A. 67	S. 317
Mugacl 161	S. 705
S. 317	CH. 45
S. 661	
S. 669	
S. 718	
S. 749	
S. 1,092	

PUNJAB

Early varieties

For Plains	For Hills
349 Jhona	100 Ram javain
370 Basmati	72 Phulpattas
246 Palman Suffaid	41 Lal Nakanda

ORISSA

Beall		Sarad		Dalua	
PTB.	10	T.	90	NIT- U.	15
CH.	45.	T.	141	PT-B.	10
CH.	47	T.	812		
N.	136	T.	1,145		
		T.	1,242		
		BAM.	12		
		T.	442		

UTTAR PRADESH

Early		Medium		Late	
N.	22	CH.	4	T.	9
T.	136	T.	1	T.	22A
CH.	10	T.	3	T.	36
		T.	21	T.	100
		N. 10 B (Not grown in the plains)			

WEST BENGAL

Aus	Early Aman	Medium Aman	Late Aman
Marichbntti	Badkalamkati 65	Nagra 41-14	Indrasail
Dharial		Bhasamanik	Tilakkacheri
Pusur		Dudsar	Acchada 108-1
Dular		Latisail	Patnai 23
Charnod.		fhingasail	Sankar
Bhatmuri 36		Badshahbhog	
Ashkata			
Bankura 1, 2, 4, 6, 15, 35			
Chinswah 3, 7, 37			

Are also grown widely

VARIETIES SUITABLE FOR SPECIAL CONDITIONS

Flood-resistant Varieties

Andhra Pradesh ..	MTU. 1
	MTU. 9
	SLO. 13
Assam Shallow water ..	Rangadurxa
	Sadbadal
	Laudumra
Deep water ..	Negheri
	Panikekoa
Bihar	BR. 13 (Introduction from Orissa
	BR. 14 -
Bombay	Bhadas 79
Orissa .	FR. 13 A
	FR. 43 B
Uttar Pradesh . . .	jaisuria
	Dudhalchi
	Saingar
	Tundia
	Kariaraa
	Kalangi

Salt-resistant Varieties

Andhra Pradesh	MTU. 1
	SLO. 13
West Bengal	Rupsail
	Sitasail
	Kumargair
	Sankar
	Acchada
Bombay	Bhurarata
	Kalarata
Orissa	SR. 26 B

Summer Paddies

Andhra Pradesh . .	MT U. 9	
	MTU. 15	
	SLO. 16	
Assam	Boro I	
	Boro IV	
	Khria	
	Kali Boro	
Madras	CO. 13	
Orissa	DI. 3	
	DI. 4	
	PTB.	10
	(Introduction	from
	Kerala)	

Some Early-maturing Chinese Varieties

CH. 2	Maturing in about 85 days
CH. 45 ..	105 „
CH. 62 ..	110 „
CH. 68 ..	110 „

Blast-resistant Varieties

Andhra Pradesh	BCP. 1
	BCP. 2
Madras	CO. 4
	CO. 25
	CO 26

Helminthosporium-resistant varieties

Bihar	T.498-2A
Madras	CO, 20
Orissa	T. 141
	BAM. 10

Breeding for High Yield. The results of breeding for high yield carried out in the country have been spectacular, and a large number of improved varieties, giving on an average an

additional yield of 10-15 per cent have been obtained as indicated above.

Although it is necessary to breed varieties for different conditions, it is possible that at least some of the improved types could be grown on larger areas in different States than at present. Their actual number could be reduced only after putting the different varieties to test in the different States. There are 445 improved strains released at present, mostly isolated from naturally variable populations, only 51 being produced by hybridization.

Under intensive method of cultivation and manuring, rice varieties capable of giving higher yield responses should be grown. Most of the existing Indian varieties do not seem to give any differential response to manures and fertilizers. As a promotional measure for this, a programme of intensive hybridization between japonica and indica varieties of rice is in progress. The japonica varieties are high yielders, give a better response to intensive manuring and possess short non-lodging straw while indica varieties have a better tillering capacity and are resistant, to some diseases and adverse climatic conditions.

Breeding for Disease Resistance. Important diseases of rice have been studied, and breeding for disease resistance has received much attention. Breeding for blast disease, caused by *Piricadaria oryzae* has been carried out in Madras State. A wide range of varieties, highly resistant to *Piricularia*, and possessing desirable agronomic characters, has been produced. Two new varieties, viz., Co. 25 and Co. 26 of Madras are notable examples. Work on the disease, caused by *Helminthosporium*, has been carried out in West Bengal, and encouraging results have been obtained. Intensive studies on all aspects of breeding for disease resistance are in progress at the Central Rice Research Institute, Cuttack, and other research stations in the States.

Investigations on another important disease, viz., foot-rot (*Fusarium moniliforme*), which occurs in a severe form in South India and Assam can be effectively controlled by treating the seed with organo-mercury compounds.

Flood-Resistant, Saline Rices. About four million acres in India are subject to floods, deep-water and salt-water

inundation. Flood-resistant and deep-water varieties, suitable for growing in varying depths of water, ranging from 4 to 20 ft., have been evolved in Assam, Uttar Pradesh and Orissa. A saline-resistant variety, SR. 26 B, evolved in Orissa is also found to be promising in Madras State. Physiological studies in Orissa have shown that tolerance to submergence and salinity may be induced by certain pre-treatment of seeds.

Breeding for resistance to salinity is in progress in several States. Several varieties and hybrid cultures are being tested at the research stations and a programme of hybridization between saline-resistant varieties

CHAPTER 11

WHEAT

WHEAT is one of the most extensively cultivated crops of the world as also one of the most important staple foods. Grains discovered at the Mohen-jo-Daro excavations (and also other evidences) indicate that the northwestern India was one of the ancestral lands of this cereal.

India accounts for about 3-5 per cent of the global wheat production. The other important wheat-producing countries are: U.S.S.R. (21-2 per cent), the U.S.A. (15-9 per cent), China (11-7 per cent), Canada (7-0 per cent), France (4-2 per cent) and Italy (4-0 per cent).

Wheat is a rabi crop. It is sown about the month of November, and requires about four to five months to mature. It is harvested between March and May.

The area under wheat forms roughly about 14-0 per cent of the total area under cereals and 10-0 per cent of the total area under foodgrains in this country. The crop is grown mainly in the northern and central parts. It is not of much significance in the South. Uttar Pradesh, Punjab, Madhya Pradesh, Maharashtra, Rajasthan and Bihar are the principal wheat-growing States. Together they account for more than 90 per cent of the acreage under it. The total area and production during 1958-59 were estimated at about 30-96 million acres and 9-7 million tons respectively.

The contribution of the major wheat-producing States was as follows:

State .	Area 1958- 59 (thousa nd acres)	Product ion 1958- 59 (thousa nd tons)	All-India percenta ge area	Produc tion
Uttar Pradesh ...	9,585	3,047	30'95	31 .43

Madhya Pradesh	6,792	1,897	2193	19.57 .
Punjab	5,315	2,275	1716	23.47'
Bombay	3,185	725	10 - 29	7 .48
Rajasthan	2,932	1,032	9 - 47	10. 65
Bihar	1,459	398	4-72	4.10
Other States	1,698	320	5-48	3.30
All India `	30,966	9,694	100.0	100.0

The average yield per acre was estimated at 701 .lb,

IMPROVED VARIETIES

Important pioneering work in the field of wheat breeding was done by the Howards during the first decade of this century, at the Agricultural Research Institute at Pusa in Bihar. Similar work was taken up in the different wheat-growing States of the country. Among the outstanding achievements of this work, mention may be made of varieties like N.P. 4, N.P. 52, N.P. 125 and N.P. 165 of the Indian Agricultural Research Institute, New Delhi, Kanpur 13 of Uttar Pradesh,; A.O. 68, A.O. 90, and A. 115 of Madhya Pradesh; Bansi 224, Jay, Vijay and Niphad-4 of Bombay; and 8-A, 9-D, C 518 and C 591 of Punjab: These wheats have given higher yields than the local varieties, and possess good grain quality. But, in general, they, have proved to be susceptible to plant diseases. Thus for instance, N.P. 125, A.O: 90, Kanpur 13 and .C 591 are susceptible to the rust diseases; C 591, otherwise an, outstandingly popular variety is also susceptible to certain other plant diseases such as loose smut, bunt and ear cockle. Even among these older wheats, however, there are some that show certain degree of resistance. N.P.. 120 is highly resistant to yellow rust and. moderately so to other two rusts (black and brown) in the adult stage. N.P. 52, N.P. 165 and Niphad-4 are partially resistant to the three rusts in .the adult stage. N.P. 120 and N.P. 165 are resistant to loose smut.

At the Indian Agricultural Research Institute, New Delhi, a new series of improved wheat varieties has. been developed during the last decade. An outstanding general feature. of these wheats is their tolerance of rust attack. Moreover, some of them,

notably N.P. 710, N.P. 718, N.P. 761 and N.P. 770 are highly resistant to the loose smut disease. N.P. 710 has shown adaptability to a wide range of agro-climatic conditions, and the quality of its grains is very good. N.P. 718 and N.P. 761 are relatively early in maturity, N.P. 718 is particularly suited to Delhi State and Rajasthan, and N.P. 761 to Bihar and Orissa. For the hills, at higher altitudes, N.P. 770 is a very good wheat; it gives a particularly impressive performance if sown a little late in the season (end of October or early November). It is bearded and has bold attractive grains.

Besides this, some strains have been developed which possess a high degree of resistance to each rust and have been utilised in breeding high yielding and rust-resistant varieties. Two such varieties are N.P. 789 and N.P. 790 which are resistant to all the races of black rust prevalent in India, except to the newly-discovered race 122. N.P. 783 and N.P. 784 are highly resistant to brown rust and N.P. 785 and N.P. 786 to yellow rust. Crosses have also been made with a view to developing varieties that combine resistance to two or all the three rusts. This labour has resulted in the production of some outstanding varieties. Among these, N.P. 797, N.P. 798 and N.P. 799 show high degree of resistance to black and brown rusts and immunity to loose smut disease while N.P. 809 possesses an appreciable



FIG. 13. Awnless wheat



FIG. 14. Awned wheat

degree of field resistance to all the three rusts. Besides, these wheats are agronomically, superior. N.P. 797 is doing well in West Bengal, Orissa and Maharashtra; N.P. 798 in Bihar (North and South)~and Gujarat; N.P. 799 in Madnapalle area of Andhra Pradesh. N.P. 809 has. done very well in the hills of northern India.

Most recently a few more promising wheat varieties have been evolved at the Indian Agricultural Research Institute. Some of them, particularly N.P. 200, N.P. 823, N.P. 824, N.P. 829 hold promise for various wheat-growing tracts of India. N.P. 823 and N.P. 824 which possess moderate resistance to black and brown rusts and high resistance to yellow rust and loose smut disease

are noteworthy for their good standing ability and marked response to high fertility conditions of soil. Of these two, N.P. 823 has also shown promise for barani and late-sown conditions at Delhi. These varieties are thus specially suited for intensive cultivation. Trials are being conducted all over India to find out their suitability to other regions; results so far available have indicated the superiority of N.P. 824 in the northern plains and of N.P. 829 at lower altitudes in the northern hills. N.P. 200, a dicoccum wheat variety possessing moderate field resistance to black and brown rusts, is recommended for cultivation in the Nilgiri and Palni Hills and other adjoining dicoccum tracts in southern India. A series of rust-resistant durum strains have also been built up recently and are in the final stages of testing.

Besides breeding for yield and disease resistance, the wheat breeding work at the Indian Agricultural Research Institute is also directed towards the improvement of quality and nutrition value. A cereal, research laboratory, equipped on modern lines, is being set up at that Institute and it will be useful to wheat breeders in the country.

The rust-resistant wheats developed in Madhya Pradesh include : Hy. 65-4, Hy. 278, Hy. 277-1, Hy. 172-2, Hy. 11-1, Hy. 11-6, Hy. 11-8 and Hy. 12. In the former Bombay State, hybridization between older wheats like Niphad-4 and a rust-resistant Kenya wheat resulted in the production of several new strains that are outstanding for their resistance to stem rust. These strains, which belong to the bread wheat group, have been named as Kenphad 21, 25, 28 and 39 and are doing well in different areas of the State. Recently, some more strains combining rust resistance with high yield, are undergoing trials in different parts of the State; among these mention may be made of K.C.N. 179, M.H.D. 177 and M.H.D. 345 which are reported to be promising. K.C.N. 179 is reported to have combined resistance to stem rust and the Alternaria disease. Work is also under way in Maharashtra and Madhya Pradesh to develop suitable rust-resistant strains of the durum group, as considerable portion of the wheat area in these is under durum varieties.

Among the wheat varieties recently developed in the Punjab, C. 217 is reported to be suitable for cultivation under barani conditions, C. 250 for humid regions such as Gurdaspur, C. 281 for the Haryana tract and C. 273 for central zones of

Punjab. C. 253 is recommended for cultivation in the Kangra Valley, and is reported to be resistant to yellow rust. Another wheat, C. 285 which is reported to be resistant to black rust has been recommended in the high altitudes of Lahaul Valley in Punjab.

CHAPTER 12

BARLEY

BARLEY IS quite an important cereal in northern India, especially in Uttar Pradesh. For a long time it was matched with wheat as an equally important food crop. In most foreign countries, however, it is now grown principally for conversion into malt, or for brewing spirituous liquors.' It is more adaptable to different natural conditions than wheat, and matures earlier. As such, it has a wider range of cultivation. In the hills it is specially important and is grown even at considerable altitudes.

CULTIVATION

In India, barley is grown mainly in Uttar Pradesh, which accounts for about 60 per cent of the total area under the crop in the country. The rest of the area is shared mainly in Bihar, Madhya Pradesh, Punjab, West Bengal and Rajasthan. The total area under it is approximately 8'1 million acres. The annual production is about 2'7 million tons. The yield per acre varies from 700 to 800 lb. It can be grown on soils unsuitable for wheat, and generally matures earlier.

The area and production figures for the quinquennium ending 1958-59 for the different States are given below:

State	Area (thousand acres)	Production (thousand tons)
Andhra Pradesh . .	9	2
Bihar . . .	877	130
Bombay . . .	33	8
Madhya Pradesh ..	408	127
Madras . . .	1	*
Mysore . . .	9	2
Orissa . . .	1	*

Punjab . . .	566	197
Rajasthan . . .	1360	602
Uttar Pradesh	4713	1501
West Bengal . .	123 ,	28
Jammu & Kashmir . .	49	13
Other States	89	16
Total ..	8238	2626

*Less than 500 tons

Barley is cultivated in the rabi season. Sowing takes place between October and December, and harvesting between February and April. It is grown under moderate irrigation, or as a dry crop in retentive soils. It is raised either by itself or mixed with a variety of crops, principally leguminous crops like peas, Bengal-gram or lentils and with wheat or mustard or linseed.

VARIETIES

As with other crops in India, attention was first paid to the collection of barley types and their study with a view to isolating the superior ones among them. Such a study was undertaken at the Agricultural Research Institute at Pusa (Bihar), and later continued at the same place as part of the work of the Botanical Sub-station of the Institute. Twenty-four types of barley were isolated and described with special reference to morphological and agronomical characters. Five of them were two-rowed barleys, and the others six-rowed ones. One of the six-rowed barleys, N.P. 21, has become established as a high-yielder suitable for eastern Uttar Pradesh and Bihar. Another variety, N.P. 13, has done exceedingly well in Delhi and the surrounding areas. Yields up to 56 maunds per acre have been recorded with it.

In the Punjab, in addition to the older varieties, Type 4 and Type 5, a green fodder barley, C. 144, has been developed by means of hybridization. It is a smooth-awned type, having relatively lesser requirements of water, and can thrive on alkali lands. Barley C.155, another variety produced by hybridization in the Punjab, is suitable for pearling and powder products. It is also reported to be suitable for malting and brewing. In Uttar

Pradesh, C. 251 has become the standard variety and is wellknown for its high quality.



FIG. 15. *Jowar*



FIG. 16. *Ragi*

CHAPTER 13

MILLETS

MILLETS is a group name for a number of cereals known as coarse grains, which are grown primarily for their grain. Their straw also makes valuable cattle fodder.

The millets comprise plants belonging to different genera and species, with widely varying habits and characters. The more common varieties cultivated in India are jowar (*Sorghum* sp.), bajra (*Pennisetum typhoides*, Stapf and Hubbard), ragi (*Eleusine coracana*, Gaertn.), korra or kangni (*Setaria italica*, Beauv.), kodon (*Paspalum scrobiculatum*, L.), kutki (*Panicum mitiari* Lam.), chena (*Panicum miliaceum*, L.) and sanjavak (*Echinochloa frumentacea*, Link. *Panicum frumentacea* Roxb.). Besides, many other allied species, grains of which are used as food, are also reported to be grown to a limited extent, or occur wild near hilly regions. They are *Setaria glauca*, Beauv., *S. aegyptiaca*, Beauv., *Panicum colonum*, L., *P. crusgalli*, L. and *P. polyanthemum*, Retz.

Most of the millets are grown in almost all the States in India. They are considered to have been cultivated and used as foodgrains from pre-historic times. Some believe that they were the first cultivated crops. Jowar is reported to have been grown in Assyria as early as 700 B.C. Millets were superseded by wheat, rye, rice, maize and potato in western Europe during the 19th century.

Millets are annual warm weather grasses. They are grown under conditions where other crops do not thrive and in regions of low rainfall. Most of the millets are of short duration i.e., of three to four months' span from seed to harvest. Their nutritional requirements are low, but they respond well to irrigation and manuring. Some of the millets, particularly jowar, bajra and ragi, are also grown as irrigated crops in well manured soils. But they are mostly grown on dry lands as rain-fed crops.

JOWAR

jowar is one of the most important millets of India. It is suitable for low rainfall areas; and can withstand drought to a considerable extent. As such, it is an ideal crop for areas which depend, entirely on rainfall. The crop has also wide scope for cultivation since it has many varieties which can be grown in different seasons, both as a dry crop and as an irrigated crop, and can produce grain as well as good fodder for cattle.

The ear-heads vary from a hard cricket-ball like shape to a long, loose; broom-like panicle. The commonest grain colour is white, but other colours such as yellow, red and various shades of brown also occur. There are two main types with regard to the stem character: the pithy or dry stem, and the juicy stem. The latter is mostly grown in areas of very low rainfall like the Deccan, and is, hence an adaptation for drought resistance. The stalks of the juicy-stem types are more relished by cattle. The variation in duration among different types is from three to six months.

In India, jowar is mainly a crop of the plains, and is grown both as a kharif and a rabi crop. The kharif crop is sown between May and July, and harvested between October and December. The rabi crop is sown between September and November and harvested between January and March.

Andhra Pradesh, Maharashtra, Madhya Pradesh, Madras, Uttar Pradesh, the Punjab, Mysore and Rajasthan are the main jowar-growing States. These together account for about 99 per cent of the total area under the crop (42 million acres), which constitutes roughly 16 per cent of the area under all foodgrains, and 20 per cent of the area under cereals. The total production is about eight million tons. The yield per acre varies from 300 to 400 lb. The State-wise area and production figures for the five years ending 1958-59 are given below:

State	Area (thousand acres)	Production (thousand tons)
Andhra Pradesh ..	6,126	1,139
Bombay	17,444	3,245
Madhya Pradesh	4,824	1,113
Madras	1,794	510

Mysore . . .	6,616	1,082
Punjab . . .	706	57
Rajasthan . . .	2,612	314
Uttar Pradesh . . .	2,245	537
Other States	69	10
Total ..	42,436	8,007

Some work on the botanical aspect of jowar has been done at the agricultural stations in Maharashtra and Madras States, side by side. with work on the improvement of production. Studies about the inheritance of most of the morphological characters have been made at the Millet Breeding Station, Coimbatore.

Work at the agricultural stations in different States is focussed mainly on the economic aspect of production, with particular reference to evolving improved varieties for higher yield of grain and superior straw. Forty-two strains have been evolved at the different agricultural research stations. Besides these, numerous types having superior economic characters are in various stages of trial in the States, where jowar is an important crop. Though numerous foreign varieties, chiefly from Africa, America and China have been obtained and grown, none of them has replaced any of the local varieties. Synthetic derivatives for resistance to the root parasite, Striga, are in advanced stages of trial in. Maharashtra and Madras States.

Production of superior hybrid varieties by using male sterile lines is being organised on an all-India basis. The work is to be coordinated with the project for the intensification of regional research on cotton, oilseeds and millets (PIRRCOM).

BAJ RA

Bajra is also one of the principal millets grown in the country, being next in importance only to jowar among the coarse grains. It is. suited to regions of low rainfall and can be grown even in tracts which receive only 17 to 20 inches of rainfall. It is seldom grown in areas where the annual rainfall is heavier than about 35 inches. Outside Asia, the grain is largely

cultivated in Africa, where it is a common article of food among both the Arabs and the natives.

In India, the crop is grown mainly in the kharif season. Sowing takes place between May and-September, and harvesting between September and February.

Andhra Pradesh, Maharashtra, Madras, the Punjab, Uttar Pradesh, Mysore and Rajasthan are the main bajra-growing States. These together account for more than 98 per cent of the total area under it. About 27 million acres are devoted to it. In other words, nearly 13'0 per cent of the total area under cereals and ten per cent of the area under foodgrains is given to its cultivation. The total production is about three million tons. The yield per acre varies from 200 to 300 lb. The area and production for the five years ending 1958-59 are given below:

State	Area (thousand acres)	Production (thousand tons)
Andhra Pradesh	1,583	312
Bombay	8,738	988
Madras	1,353	293
Mysore	1,255	120
Punjab	2,435	287
Rajasthan	9,064	712
Uttar Pradesh	2,750	592
Other States	578	111
Total ,.	27,756	3,415

It differs from other millets in that It is protogynous, i.e., the stigmas become fertile and receptive before the anthers-mature and dehisce. So, normally, it is cross-pollinated. Hence, improvement of the crop by pure line selection has been found to be not quite promising. Mass selection is the better method.

In recent years, production of hybrid, seed from selected parents has been in progress in Coimbatore. Two hybrid combinations have been found to excel local varieties in yield of grain in parts of. Madras State, and the hybrid seeds are being

produced on a bulk scale and distributed. Work on similar lines to exploit hybrid vigour is in progress in Maharashtra also, and one hybrid combination has been found to be promising. Improvement by hybridization, by exposure to X-ray, and by colchicine treatment is in progress in the Punjab. Breeding of improved varieties is being done in Uttar Pradesh and Bihar also. Earlier work on this crop has resulted in the isolation of eight strains by selection in Madras, four strains in Maharashtra, two in the Punjab, and one in Uttar Pradesh.

RAGI

Ragi has many valuable features which mark it off sharply from other foodgrains. It is one of the hardiest crops, suited for dry farming. It can grow under conditions of very low rainfall, and can withstand very severe drought, reviving again with a good shower of rain with remarkable vigour. It is a grain of great nutritive value, and is considered more sustaining for people doing hard physical work than any other grain. It can be grown as a dry crop as well as under irrigation. Unlike other crops; both the plant and the grain remain free from pests and diseases. Rag. grain can be stored for many years-even up to fifty years-without damage, if kept away from moisture. The straw is considered a valuable food for the drought as well as milch animals.

In India; like bajra and maize, ragi is sown in the kharif season. Sowing takes place between May and August, and harvesting between September and January. In Andhra Pradesh and Madras, sowing and harvesting continue almost throughout the year.

The crop is grown mainly in Andhra Pradesh, Madras and Mysore which together account for roughly two-thirds of the area under it in the country. Mysore is by far the most important ragi-growing State accounting for thirty-seven per cent of the total area of the crop. The remaining area under the crop is shared chiefly by Bihar, Maharashtra Orissa and Uttar Pradesh. The total area and production of ragi in the country are 5.7 million acres, and 1.7 million tons, respectively. The yield per acre varies from 600 to 700 lb. Table on the next page gives the,

State-wise area and production for the quinquennium ending 1958-59.

The important variations observed are in ear-head shape and plan pigmentation. The seed coat is generally brown in colour; a few type

State	Area (in thousand acres)	Production (in thousand tons)
Andhra Pradesh ..	782	242
Bihar	392	74
Bombay	680	210
Madras	874	351
Mysore	2,162	705
Orissa	251.	48
Uttar Pradesh	478	91
Other States	124	26
Total . .	5, 743	1, 747

with white grains also occur. The genetics of this millet has been studied in some detail at Coimbatore. Sixteen improved strains of ragi have been evolved in Madras State, and two strains each in Mysore and Andhra Pradesh. These- are being grown in different parts of these States. Breeding of this millet has been undertaken in recent years in Maharashtra, Bihar and Uttar Pradesh.

SMALL MILLETS

Cereals other than rice, jowar, bajra, maize, ragi, wheat and barley grown in India are grouped as small millets. They are comparatively of minor importance. Broadly, they include the following crops

State	Crop
Maharashtra	Kodra, Vari, Sava, Bauti and Badli
Madhya Pradesh ..	Kodon, Kutki, Rala, Sawa and Rajgura

Andhra Pradesh & Madras	.Korra, Varagu and Samai
Uttar Pradesh ..	Kodon, Kutki, Nakun, Sawan and Chena
Mysore . . .	Navane,.Seaa, Haraka and Baragu

These crops are generally sown in the kharif season. Some are, however, sown in the rabi season as well. The principal producing areas are: Andhra Pradesh, Bihar, Maharashtra, Madhya Pradesh, Madras, Uttar Pradesh and Mysore. They together account for about 96 per cent of the total area under these cereals. Orissa and Rajasthan are the other important producing States. '

The total area under these cereals is roughly 13 million acres. The production comes to two million tons annually. The yield per acre varies from 300 to 400 lb.

The grains of these millets are enclosed in persistent husks which could be separated only by mechanical means. When the husks are removed, the grains are more or less white or creamy in colour. They are grown mostly in regions of low soil fertility and rainfall. The most important among these millets is korra (*Setaria italica*, Beauv). It is grown in Madras State on about one million acres. Seven improved strains of this millet have been evolved, and are being multiplied and distributed. Some work on the genetics of korra has also been done. Isolation of improved strains, resistant to leafrust, a serious disease of the crop, has been receiving attention in recent years. The other small millets which are cultivated to some extent are *Paspalum scrobiculatum* L., *Panicum miliare* Lain., *Panicum miliaceum* L. and *Echinocloa frumentacea* Roxb. Study of these millets has also been in progress in Madras State. Two high-yielding strains of *Paspalum* have been evolved, and are being distributed to the cultivators. Types of the other millets are being maintained at the Millet Breeding Station, Coimbatore.

CHAPTER 14

MAIZE

MAIZE, which is also known as " Indian corn' or simply as ` corn' is a food crop of considerable importance in many parts of the world, especially in U.S.A., which produces nearly 57 per cent of the total maize grown in the world as compared to about 1.4 per cent produced in India. The other important maize-producing countries are: China (4.7 per cent), Brazil (4'4 per cent), U.S:S.R. (3'3 per cent), Manchuria (2'9 per cent), Yugoslavia (2'4 per cent) and Mexico (2'3 per cent).

In India, maize is grown chiefly in Andhra Pradesh, Bihar, Maharashtra, Madhya Pradesh, the Punjab, Uttar Pradesh, Jammu and Kashmir, Rajasthan and Himachal Pradesh. Uttar Pradesh leads all other States by a long way and accounts for more than a quarter of the national area. These together account for more than 95 per cent of the total area under it. The other important maize-producing States are Orissa and West Bengal. It commands an area of approximately 8-9 million acres, which constitutes roughly four per cent of the total area covered by cereals. The production is of the order of 2'5 million tons. The yield per acre varies from 600 to 700 lb.

The acreage under the crop and production in 1955-56 were as follows:

State	Area (thousand acres)	Production (thousand tons)
Andhra Pradesh ...	629	116
Assam ...	38	7
Bihar	1,542	363
Bombay ...	492	73
Madhya Pradesh	1,067	201
Madras	15	6
Mysore ...	29	7
Orissa ...	60	9

Punjab	1,078	526
Rajasthan	1,356	500
Uttar Pradesh	2,571	760
West Bengal	143	40
Jammu and Kashmir . .	409	129
Other States	282	68
Total ..	9,553	2,907

The crop is sown mainly in the kharif season in India. In Andhra Pradesh 11 per cent of the area is cropped in the rabi season with the help of well irrigation. Sowings take place between May and July, and harvesting is done between August and November. The rabi crop is sown in November-December and harvested in March-April. It is of special importance in the hilly and sub-montane regions of the country, where it forms the staple diet of the people, particularly in the winter months. In the northern parts, it is also extensively grown as a fodder crop. The flint' variety, among which the red-grained biotype predominates, forms the bulk of the maize crop grown in India.

MAIZE BREEDING

The work on maize breeding started at the Indian Agricultural Research Institute, New Delhi, and in the Punjab State in 1944-45. Subsequently, a number of research schemes were initiated in the principal maize-growing areas. Isolation of inbreds has been carried out under this scheme. Production of top crosses, and single and double crosses has also been attempted at a number of centres. In the Punjab, work on sweet corn has also been done. At Almora, production of two U.S. double hybrids N.C. 27 and U.S. 13 was undertaken after the multiplication of parental inbreds. Work at the LA.R.I. was on a more elaborate scale. A coordinated scheme for research on hybrid maize has now been started by the establishment of four main research stations at Srinagar, the Indian Agricultural Research Institute, the Tarai Farm in U.P. and Hyderabad, with nine sub-stations in the various maize-growing regions.

CHAPTER 15

PULSES

ABOUT one-seventh of the cultivated area of the country annually grows the important group of crops commonly known as pulses. These crops figure prominently in the crop rotations and crop mixtures practised by the farmers. Being leguminous crops they help in the maintenance of soil fertility, and being rich in proteins, they supply a major part of the protein requirements of the predominantly vegetarian population of the country. Some of the pulses serve as excellent forage and grain concentrates in the feed of the large cattle population of the country.

Of all the pulse crops of India, gram and tur are the most important. The percentage of area and production of the major pulses are given below

Botanical name	English: or vernacular name	Percent age Area	of total Production
<i>Cicer arietinum</i> ,	Gram or Bengal-gram (chana) . .	41 . 2	52 . 4
<i>Cajanus cajan</i>	Pigeon-Pea, Red-gram (arhar or tur) . . .	10.3 ,	14.9
<i>Phaseolus mungo</i>	Black gram (Mash, Urad or kalai)	5 . 8	3 . 4
<i>Phaseolus aureus</i>	Green-gram (Mung or mug) ..	5.9	2.9
<i>Eraum lens</i>	Lentil (masur)	2 . 3	1 8
<i>Dolichos biflorus</i>	Horse-gram (kulthi or gahat) . .	7 . 3	3. 7
<i>Pisum spp.</i>	Peas (matar or vatana) ; . .	5.1	6.3
<i>Lathyrus sativus</i>	Lakh or khesari	3 . 4	2' . 4
<i>Phaseolus acanthifolius</i>	Moth or matki	7..3 ..	3 . 0

Other pulses 11 .4 9 .3

GRAM

Gram which is also known as 'Bengal-gram' is the most important of the Indian pulses, and has a wide range of cultivation throughout the country. It is grown in many other countries also, e.g., Italy, Greece, Rumania, Russia, Egypt, North Africa, Rhodesia, East Africa, Iran, Turkey; Central and South America, and parts of Australia.

In India, gram is sown as a rabi crop at the end of the rainy season. Sowing takes place between September and January, and harvesting between February and April.

The crop is grown mainly in Bihar, Maharashtra, Madhya Pradesh, the Punjab, Uttar Pradesh and Rajasthan. These together account for more than 90 per cent of the total area under it. States of lesser importance are Andhra Pradesh, Mysore and West Bengal.

The total area under "gram in India is about 23 million acres, and the annual production nearly five million tons. The yield per acre varies from 400 to 600 lb.

ARHAR OR TUR

Arhar which is also known as 'red-gram', ranks second only to gram in importance. Although it is grown almost all over India, it is chiefly consumed in Bihar, eastern Uttar Pradesh, parts of Central India and South India.

It is grown as a dry crop mixed with cereals like jowar, bajra and ragi. In North India, however,, the crop is sometimes irrigated.

Arhar is sown in the kharif season from May to July, and is harvested in about six to eight months' time (i.e., from December to March) in the rabi season. It is mainly grown in Andhra Pradesh, Bihar, Maharashtra, Madhya Pradesh, Uttar Pradesh and Mysore, which together account for roughly 95 per cent of the total area under it. The area covered by it is about 5'8 million acres, and the annual production is between 1.7 to 1.8 million tons. The yield per acre varies from 600 to 700 lb.

PULSES OTHER THAN GRAM AND ARHAR

Pulses other than gram and arhar grown in India comprise urad or mash, mung, moth, masur, kulthi, peas, lakh or khesari and other miscellaneous pulses. These are grown all over the country in the kharif as well as rabi seasons. Andhra Pradesh, Bihar, Maharashtra, Madhya Pradesh, Madras, Orissa, Uttar Pradesh, West Bengal, Mysore and Rajasthan are the important producing States, and account for more than 95 per cent of the total area under these. Assam and the Punjab are the other producing States.

The total area under these crops in the country is about 264 million acres, and annual production comes to about 311 million tons. The yield per acre is in the neighbourhood of 300 lb.

IMPROVED VARIETIES OF PULSES

Gram. In Bihar, B.R. 17, B.R. 65, and B.R. 77 have given 5.7 per cent higher yields as compared to the standard type S. 4 in south Bihar.

In Maharashtra, among the sprains selected as promising are Khanapur 2-4, F.S. 30, BN 7, BN 10, BN 30 and BN 31.

In Hyderabad, strain 63-8-12-41 has given, on an average, about 11 per cent higher yield than the local varieties in the district trials during the last three years.

In the State of Madhya Pradesh, strain Gwalior 2 was developed for the northern region and Ujjain 21 and Ujjain 22 for the southern region. Gulabi and Bhilsa Green are considered quality grams for the southern region.

In Madras, Co. 1 evolved at Coimbatore is recommended for the districts of Coimbatore and Rayalaseema.

In Mysore, three selections, yielding appreciably more than the local varieties, are under trial.

In Uttar Pradesh, Type 87 has covered considerable areas in a majority of the districts and is rapidly becoming popular because of its vigorous growth, high grain yields, and very superior grain size and quality as well as adaptability to a wide range of growing conditions. For the drier areas of south U.P., a hybrid between Type 87 and a local gram named Type 1, is now under distribution.

Arhar. In Bihar, three early-maturing strains, B.R. 13, B.R. 59, and B.R. 172, which are ready for harvest by the end of October, have been recommended. Medium-maturing strains, B.R. 60, B. R. 65, and B.R. 71, and late-maturing strains, B.R. 15, 7S, B.R. 10, and B.R. 17 (the last two having an erect habit of growth), have been finally selected as superior strains.

In Maharashtra, strains F. 18 and F. 62 have been finally selected for trials in the districts on account of high yield and wilt resistance.

In Hyderabad, four of the improved strains are under district trials.

In Madras, strain SA 1, selected at Salem Sub-station, has been recommended for the central and southern districts of the State.

In Uttar Pradesh, Type 17, which gives high yield and possesses the qualities of palatability and moderate wilt resistance, has been under general distribution on account of better yields than the local varieties. Some better yielding types are under final tests. Type 1 has been released as a good early variety maturing by the end of November. More recently, another late variety, Type 105, has been released as a superior yielding variety.

Urad. In Bihar, types B.R. 10, B.R. 11, B.R. 68, and S:T. 8, giving 12 to 27 per cent higher yields than local varieties have been recommended for the southern districts.

In Madras, Type VZM, 1, evolved at Vizianagaram, is recommended for the northern coastal districts (now in Andhra Pradesh).

In Orissa, S. 1601 has consistently yielded considerably more than the local varieties in trials since 1947-48, and is recommended for multiplication.

In Uttar Pradesh, Type 9 (early variety) and Type 27 (late variety) are under distribution.

Mung.. In Bihar, B.R. strains 1-6 and S.T. 7 have been finally selected for the southern districts. B.R. 1 has green seeds and is medium in maturity. B.R. 2, B.R. 3, and B.R. 4 have black seeds and are early maturing; and the remaining three have yellow seeds and are late in maturity. The increase in yield over

the local Type S.T.I. has varied, on an average, from 3 to 14 per cent.

In Maharashtra, selections 781 and 1-49 from the early China mung variety are being finally tested in the districts.

In the State of Madhya Pradesh, the early strain Krishna 11 has been found suitable for the northern region.

In Madras, Co. 1, evolved at Coimbatore, has proved suitable as a dry-land crop in the southern districts.

In Orissa, S. 150 has consistently yielded significantly more than the local variety, and is being released for general cultivation'

In Uttar Pradesh, mung Type 1 has figured prominently in several districts as a short duration legume to replace monsoon fallows, and to serve as a dual-purpose green manure and grain crop.

Pea. In Bihar, B.R. 2, B.R. 12 and B.R. 118 among the white flowered strains, and B.R. 178 among the purple flowered strains, giving 11 to 26 per cent higher yield than the local varieties, have been recommended.

In Uttar Pradesh, the remarkable yielding ability and quality of white pea Type 163 have made it a great favourite in most districts of the State. At places it has given to the growers double the money return compared to the local peas on account of better yields (50 to 60 per cent higher) and quality (securing 30 to 50 per cent better price). Type 19 is recommended as a high quality table pea of good yield.

CHAPTER 16

POTATO

THE potato is a wholesome food and an excellent source of carbohydrates. It easily yields about two and a half times more calories per acre than any other cereal. It does not occupy the land for a long time and the returns are quick. In the plains, where the bulk of area under potato cultivation lies, two successive crops can be raised between September and March. As a summer crop it is also grown in the hill regions where its cultivation extends over 10,000 ft. above the sea level.

Special advantages, which the potato offers as a source of food, have led to its increased culture in all the Western countries, where for every 100 acres of cereals, about 20 acres are devoted to the potato. In India, however, only one acre of potato is found for about 300 acres of cereals. That is why we in this country consume only about 8 lb. per man per year as against over 300 lb. and more consumed by a man in several Western countries.

Besides an efficient source of carbohydrates, the potato has a small percentage of rather high quality protein. It contains useful and assimilable quantities of several important minerals like iron, calcium, magnesium, sulphur, chlorine, potassium and phosphorus. Trace elements like copper, boron, manganese and iodine, which in small quantities are also required to maintain good health, are present in the tuber. The main virtue of the potato, however, lies in its high vitamin C content and appreciable quantities of vitamins B₁ and B₂.

The important potato-growing countries are U.S.S.R. (31·1 per cent), Poland (12·5 per cent), West Germany (9·4 per cent), France (5·4 per cent), the U.S.A. (3·9 per cent), the United Kingdom (2·1 per cent), Czechoslovakia (3·1 per cent) and China (0·8 per cent). India accounts for only 0·7 per cent of the world production. Imports of potatoes into India (mainly for seed purposes) come from Burma.

CULTIVATION

The potato was introduced from Europe into India in the early part of the 17th century. In the early days it was considered more as a novelty than a staple food, but interest in its cultivation gradually increased and today it occupies an area of about eight lakh acres out of which nearly 90 per cent is cultivated in the plains mainly as a winter crop during September-March and ten per cent in the hills as a summer crop during

March-October. In the hills it is grown as a rain-fed crop while in the plains it is usually grown as irrigated crop. Hill produce is valued as seed for late rabi planting in the plains.

The potato is cultivated mainly in the States of Assam, Bihar, Uttar Pradesh and West Bengal. These together account for about 80 percent of the area under it in the country. Maharashtra, Madhya Pradesh, Madras, Orissa, the Punjab and Himachal Pradesh are the other important potato-producing States. Average output per acre is about 5,546 lb. but under good cultural conditions yields of 20,500 to 30,000 lb. per acre are by no means uncommon. The total area and production of potatoes in India in 1957-58 were 7,94,000 acres and two million tons, respectively. Figures for 1957-58 for the more important potato producing States are given below

POTATO AREA AND PRODUCTION 1957-58

State	Area (thousand acres)	Production (thousand tons)
Uttar Pradesh	259	716
Bihar	155	281
West Bengal	123	389
		7
Assam	75	120
Other States	182	460

Although 28 distinct commercial varieties are found growing in the country, yet from the commercial point of view

only Phulraa, Darjeeling Red Rouad, Satha, Gola, Magnum Bonum, Up-to-Date and Great Scot are of importance. The first four which are the desi varieties are chance survivals of older introductions. These are mainly grown in the plains. The European varieties are cultivated in the hills. Besides, several new improved varieties have been selected and evolved by the Central Potato Research Institute, Simla. The varieties, new and old, which are important from commercial point of view are given below.

VARIETIES FOR THE PLAINS

Late Maturing Varieties. These varieties take four and a half to five months to mature and generally yield heavy crops.

Phulwa. It is the old desi variety still persisting in the country. It produces good yields under a wide range of conditions and is grown to a considerable extent in the plains of North India. It yields a crop of round, small to medium-sized tubers. The tubers are usually white with deep coloured eyes. (Phulwa being a mixture of several distinct clones). Splashing of red or purple may also occur on the tubers. The flesh is yellow, waxy and firm and does not break on cooking. It has an excellent keeping quality and can be successfully stored by the ordinary country methods of storage. A- good cooking quality and excellent keeping quality are the chief merits of this variety.

Kufri Safed. It is a high yielding disease-free clone of Phulwa developed at the Central Potato Research- Institute, Simla. It has large foliage and yields a heavier crop of tubers than Phulwa. liufri Safed can profitably replace Phulwa in Uttar Pradesh, Bihar, Orissa and Madhya Pradesh. If easy marketing facilities are not available, Kufri Safed should be preferred.

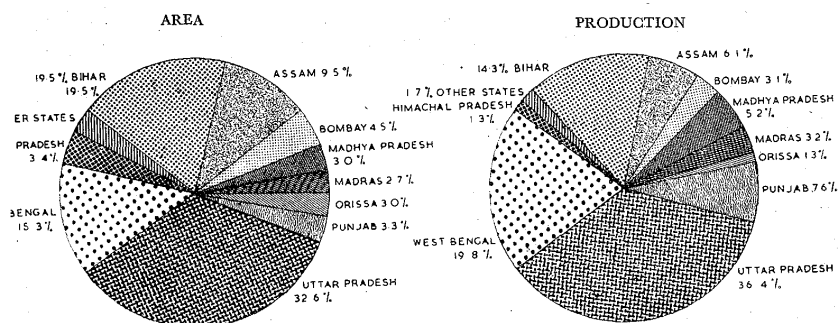


Fig. 17. Potato area and production

Darjeeling Red Round. It is an important old desi variety. It matures in three and a half to four months time. It is extensively grown in the plains of North India. It is an excellent cropper and produces a large bulk of mostly medium-sized, red rather rough and irregular round tubers. The flesh is yellow (sometimes with purple colouration near the cortex), waxy and firm and does not break on cooking. It has, however, a poor keeping quality. Seed stocks should preferably be stored in a cold store. Excellent cooking and cropping qualities have won favour for this variety: The existing commercial crops are a mixture of several types.

Kufri Red. It is a high yielding disease-free clone of Darjeeling Red Round selected at the Central Potato Research Institute, Simla. Kufri Red is very popular in Uttar Pradesh and Bihar and is rapidly replacing Darjeeling Red Round. It is also very suitable for cultivation in the Punjab, Orissa and West Bengal.

Early Maturing Varieties. These varieties mature in about three months.

Satha.. It is an old desi potato resembling Phulwa. It yields a crop of small-sized tubers in two to two and a half months. Where earliness (as in Bihar Sharif) is the main consideration, a low yield of 40 to 60 maunds per acre may be remunerative due to the very high prices prevailing in the month of November. It is a variety of local importance in Bihar and the eastern districts of Uttar Pradesh.

Gola. It is an old desi potato. The commercial Gola is a mixture of several types which are all poor yielders. The

dominant type Gola B (Gola Chonchiya) has large pear-shaped white tubers with deep-set eyes. This variety has a low cropping power as its seed stocks have fully degenerated due to virus infection. It has a cream-coloured flesh and is close in texture and keeps fairly firm on cooking. It should be stored in cold storage.

UP-to-Date (disease-free clone): Disease-free clone of Up-to-Date is the progeny of one selected plant originally imported by the Central Potato Research Institute, Simla, from Northern Ireland. The variety is being multiplied on a commercial scale by the Himachal Pradesh Department of Agriculture and is now rapidly replacing the old Numbri potato. It is an excellent cropper, yielding a clean crop of white, medium to white flesh and cooks readily, but on prolonged cooking the flesh breaks, particularly in the case of freshly harvested potatoes. It is an excellent variety for use as mashed or baked potatoes.

It has a wide adaptability and is very suitable for cultivation in the plains of the Punjab, Uttar Pradesh, Bihar, West Bengal, Maharashtra, Mysore, Andhra Pradesh, Rajasthan and Madhya Pradesh.

Kufri Kuber (Hybrid 2236). This hybrid,, bred by the Central Potato Research Institute, has proved to be an excellent variety for Bihar and Uttar Pradesh. It is also likely to do well in Orissa, Rajasthan, and Madhya Pradesh. It produces a heavy crop of large to medium sized, oval white tubers. The flesh is firm and pale yellow. That it does not degenerate rapidly in the plains, is one of its important virtues.

Craigs Defiance. It is a variety introduced from Scotland. It is earlier than Up-to-Date and Kufri, Kuber by about a week or ten days. It has long, large-sized white tubers of excellent quality. It has been found particularly suitable for the plains of the Punjab where it is in demand as an early potato.

VARIETIES FOR THE HILLS

Up-to-Date (disease-free clone). It is extensively grown in the hills of Himachal Pradesh and Uttar Pradesh.

Craigs Defiance. It is rapidly replacing the local potatoes in Chamba hill region in Himachal Pradesh.

Darjeeling Red Round This variety is still popular in the Darjeeling hills. However, in recent years a new disease known as 'Wart' has caused considerable damage to the crop in these areas. 'Wart' is now proving a limiting factor to successful potato cultivation in Darjeeling district and adjoining hill tracts. Darjeeling Red Round being particularly susceptible to

'Wart' disease, it is not advisable to use potatoes raised in Darjeeling area as seed.

Great Scot. It is a variety exclusively grown in the Nilgiris in Madras State where it is known as Mettupalayam. It usually does not thrive in the hilly regions of North India nor is it suited for culture in the plains. Its tubers are round, somewhat flattened, white skinned and with medium deep eyes. It has a. white and rather firm flesh.

Kufri Kundan (Hybrid 9). It is a hybrid evolved at the Central Potato Research Institute, Simla. It yields round, well-shaped white potatoes and does well under a wide range of conditions in the hills of North India. It can stand wet soil conditions and where Up-to-Date is grown with risk, particularly on wet heavy soils, Kufri Kundan can be grown with advantage. Its flesh is white and firm and does not break easily on cooking. It shows considerable degree of field resistance to late blight.

President. III is an European potato variety with excellent white, round, oval-shaped tubers. It has been found as a good commercial potato for the Nilgiri hill regions of Madras.

MULTIPLICATION OF DISEASE-TREE SEED

Several virus diseases prevalent in the country are responsible for rapid degeneration of seed potatoes in the country. Widespread use of degenerated seed stocks is one of the chief reasons for existing low yields in the country. Crops raised from degenerated seed potatoes also fail to respond fully to good cultural and manurial treatments. For ensuring high yields, it is, therefore, necessary to use, reasonably healthy seed. Through a planned seed potato production programme at the Centre and the State levels, healthy seed stocks of good quality are becoming increasingly available for use by the cultivators. Under this programme, disease-free seed stocks are

built at the Central Potato Research Institute through a series of elaborate laboratory tests. The disease-free nucleus stocks thus developed are multiplied in high hill regions at Kufri (Himachal Pradesh) and Mukteshwar (Uttar Pradesh) Stations of the Institute. Foundation disease-free stocks of commercial varieties thus produced are annually passed on to several State Departments of Agriculture for largescale multiplication, first in the hill regions and later in the plains. Under this arrangement disease-free seeds of Up-to-Date, Craigs Defiance, Kufri Red, Kufri Safed and Kufri Kundan are available in sizable quantities with the Himachal Pradesh and the Uttar Pradesh Departments of Agriculture. Arrangements have also been made by the Central Potato Research Institute for production of disease-free foundation stocks of Great Scot, President and liufri Kuber for use in the Nilgiri Hill regions of the South.

CHAPTER 17

TAPIOCA

Tapioca, also known as cassava, is a native of tropical South America. Brazil is reported to be the place of its origin, but its cultivation has now spread nearly to all the tropical countries of the world, where it forms an important article of human food, as well as food for livestock. It is also used for the manufacture of starch, power alcohol, glucose, and other derivatives of starch.

According to MacMillan, tapioca was introduced into Ceylon and India by the Portuguese in the 17th century, while Burkhill states that it was freshly introduced from South America into India in 1840.

In acreage and total production of tubers, tapioca is the foremost tuber crop in India. Kerala is the only place where tapioca is extensively cultivated. While attempts have been made to extend its cultivation into other parts of the country, Kerala remains the chief producing area, with more than half a million acres under the crop.

Botanically, the tapioca plant is *Manihot utilisima* Pohl., and belongs to the natural order Euphorbiaceae. The ' Ceara rubber' tree, *Manihot glaziovii*, is closely related to it. ° Tapioca is known by several local names in different countries. In the Americas, it is more commonly known as cassava or manioc, while the name tapioca denotes certain market forms of its starch. In the Philippines, there are several native names for this plant, ' Camoteg Cahoy ', meaning tree of sweet potato, being probably the most common. In Kerala, it is known as kappa or maracheeni.

Tapioca is a perennial plant, and some of the branching varieties, if allowed to grow indefinitely under favourable soil and climatic conditions, attain the size of a small tree. Under cultivation, the plants are harvested from the eighth to tenth month after planting.

The plants have tall, thin and straight stems, which are marked along their length by numerous leaf-scars. Some of the varieties are non-flowering, and do not branch. All flowering

varieties branch at the top before flowering and some profusely in a trichotomous manner.

CULTIVATION

Tapioca is mainly a tropical crop, and has not been successfully cultivated on a large scale beyond the 25th parallel on both sides of the Equator. It thrives best under a warm, humid climate, such as exists on the West Coast of South India, in Malaya, Java and other places. The crop does not stand much cold, and even a light frost kills all the leaves. The crop can be grown up to an elevation of 3,000 feet in the tropical belt.

If the crop is harvested during periods of heavy rainfall, as is done in certain regions, the stems are not stored for more than a week or ten days before planting. At present, planting in Kerala is done almost throughout the year. This is possible as this area gets two monsoons, and the rain-free period is usually very short. - However, the main planting season is in April-May.

The crop is usually harvested from the eighth to the tenth month after planting by pulling out the plants with hands. The tubers are then severed from the stem with a sharp knife, collected in baskets and marketed.

The yield is highly variable. The average yield per acre in Kerala is about five to six tons of raw tubers. In Malaya and other places, yields up to 25 tons per acre have been obtained. At the Tapioca Experiment Station at Trivandrum, production up to 20 tons of tubers per acre has been achieved from high-yielding hybrids under intensive cultivation.

As the fresh tubers do not keep in good condition for more than a week, they are usually preserved as dried chips. The tubers are cut into thin round slices, and dried in the sun after parboiling (by plunging the slices in boiling water for about ten minutes). Parboiling helps to reduce insect attack on the chips during storage.

VARIETIES

Varieties differ greatly in the colour of the plant parts. The stems may be greenish white, green, light or deep reddish brown or tinged with purple. The true colour of the stem is seen only in the young top portion, the older portion being covered by a thin

whitish layer of periderm (cork). The leaves are five to nine-lobed, with a long petiole, the colour of the petiole and veins of the leaves corresponding to that of the stem. The plant grows to a height of 4 to 15 feet, depending on the variety and the environment.

CHAPTER 18

GROUNDNUT

A LITTLE Over half a century ago, groundnut also known as peanut or monkey-nut was only a food crop of minor importance, grown over small areas. Now, however, its cultivation extends over millions of acres in the world. Its original home is believed to be Brazil in South America, but the chief centre from which this world-wide expansion commenced is West Africa from where the French industrialists introduced it into the French colonial possessions. Thereafter, it spread to other parts of the world.

India is the largest groundnut-producing country in the world, and contributes nearly 345 per cent of the world production. The- other important groundnut producing countries are China (201 per cent), the U.S.A. (5'6 per cent), French West Africa (8'7 per cent), Nigeria (6 per cent).

Groundnut is cultivated principally as an oilseed, but considerable quantities are consumed directly as food. It is also a good rotation crop, having good soil recuperative value and is also an efficient cover against soil erosion, besides being a good forage for cattle. -It is, however, as a source of oil that it finds its largest use. In Europe and America, groundnut oil enters largely into the manufacture of 'margarine'. In India, it is used for cooking purposes, either as such or after conversion into vegetable ghee, also known as Vanaspati.

CULTIVATION

Though a tropical crop, the cultivation of groundnut extends to both the tropical and sub-tropical zones, and even into the higher altitudes, provided the summers are enough to permit the crop to ripen. It is grown both as a dry and irrigated crop. For really good yields, it requires a higher rainfall than the ordinary dry-land crops. About 30 to 35 inches of rainfall should be considered necessary, though the crop is grown even under a rainfall of 20 inches. In the latter case, however, the yields are

low. Unlike other dry-land crops, it can also stand higher rainfall of 50 to 55 inches.

Groundnut is generally grown as the only dry-land crop of the year, since the variety generally sown covers the ground for quite five months. In recent years, however, some early maturing varieties, which require only 90 to 100 days, have been introduced; and it has become possible to raise a second crop also. Where it is cultivated under irrigated conditions, it forms one of the two crops raised in the same year. Groundnut is grown generally by itself, but the practice of taking a mixed crop is also becoming popular. It is a low growing crop and can, therefore, be grown under taller crops like jowar, castor, bajra, arhar and cotton.

In India, groundnut is sown between May and July, and harvested between September and December. It is mainly grown in Andhra Pradesh, Maharashtra, Madras and Mysore which together account for about 88.3 per cent of the total area under it. Madhya Pradesh and Uttar Pradesh are the other important groundnut-producing States. The area covered and the pod yield is 14.46 million acres, and 4.27 million tons, respectively. The yield per acre during 1957-58 was estimated at 662 lb. (nuts in shells).

IMPROVED STRAINS

State	Strain	Special features	Average acre yield (in lb.)	Seed source
Madras	TMV. 1	Spreading variety; yields 25 per cent more drought-resistant type; easy to harvest, pods remain attached to the plants.	1,500	Director of Agriculture, Cheplcur,
	TMV. 2 (rain-fed)	Bunch variety; short duration crop, yielding 20 per cent more, suitable for tracts where two crops are grown during the main	1,000	Madras. -do-

		season, cannot stand long periods of drought.		
	TMV. 2 (irrigated)	Bunch variety, yields 25 per cent more, cannot stand long periods of drought.	2,000	-do-
	TMV. 3	Spreading variety; yields 25 per cent more, has a high shelling out-turn and natural test weight.	1,500	-do-
	TMV.4	Spreading variety; well-suited for growing as an irrigated crop, yields 30 per cent more than the local varieties.	3,500	-do-
Punjab	PB. Ground nut No. 1	Spreading variety; a high yielder, shelling percentage 70, drought resistant and resistant to leaf spot.	1,500	Director of Agriculture,
Mysore	HG. 7	Spreading variety; shelling percentage	558 (rain-fed) 1,200 (irrigated)	Punjab, Chandigarh. Director of Agriculture, Mysore, Bangalore.
	HG. 8	Bunch variety; shelling percentage 79.	700	-do-
	HG. 10	Bunch variety; shelling percentage 74. Drought resistant and partially resistant to leaf spot disease.	900-1,000	-do-

State	Strain	Special features	Average acre yield (in lb.)	Seed source
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Bombay	Spanish Improved	Bunch variety; resistant, high yields, suffers less from Tikka leaf spot disease, shelling percentage 74.	drought 1,500	Director of Agriculture, Bombay, Poona.
	Kopergaon NO. 1	Semi-erect variety; suitable for heavy soils, shelling percentage 72.	1,200	-do-
	Kopergaon No. 3	Bunch variety; suitable for light soils, three seed pods, shelling percentage 66.	1,200	-do-
	Improved Small Japan	Bunch variety; early, easy to harvest, shelling percentage 72.	742	-do-
	A.K. 12-24	Bunch variety; suited to medium and heavy soils, used on a big scale for oil extraction, shelling percentage 73.	1,119	-do-
	A.K. 10	Bunch variety; most suitable for domestic purposes, shelling percentage 66.	1,000-1,200	-do-

There are four important commercial types of groundnut grown in India. They are: Coromandel, Bombay Bold, Spanish Peanut, and Red Natal.

Coromandel. This type is also called Mauritius, a machine-shelled type originally imported from Mozambique. It is grown in Bombay and Madras States. It is a spreading type with a duration of 42 months. The shelling out-turn works out to 77 per cent and the oil content to 45 to 50 per cent.

Bombay Bold.' This type is grown in Sholapur; Barsi, Latur, Gulbarga, Kolhapur, Karad, Gujarat and Kathiawar. It is also called the 'big Japanese type'. The pods are larger than those of the Mauritius, and are well defined. The kernels are oval

and also larger. They are redskinned and darken quickly. The oil content varies from 43 to 47 per cent.

The Spanish Peanut or Khandesh Natal or Peanut. This type is grown in Khandesh (Maharashtra), Madhya Pradesh, Pollachi, Coimbatore (Madras) and Pondicherry. It is a bunch type, having a duration of 32 months. Originally, it was imported from Spain, but was later replaced by seed obtained from America. The pods of this type are smaller than those of Coromandel. The kernels are small and round with a rose coloured skin that peels off easily and darkens with age. The shelling percentage works out to 78 and the oil content to 50 to 54 per cent.

Red Natal or LaL Boria. This type is grown in Gujarat, parts of Kolhapur; Karad, Berar, Pollachi and Madhya Pradesh. This type is also called Lalwana or 'small Japanese'. The kernels are round, deep, and dark red in colour. The duration of the type is about 95 days. The oil content is 49 to 51 per cent.

CHAPTER 19

CASTOR

AMONG the oilseeds grown in India, castor occupies an important position in regard to the quantity of seed and oil exported. India is the most important source for the world's supply of castor oil, which finds a number of uses for domestic, medicinal and industrial purposes. The castor oilcake is a valuable fertilizer. It is, however, unsuitable as cattle feed due to the presence of the poison 'ricin'.

Castor seed can be grown in dry areas, and can also stand very heavy rains and floods. It can grow up to an elevation of 5,000 feet, provided frost does not set in before it matures. It can be grown in all States where maize can be grown.

It is raised almost entirely as a dry crop. It occupies the ground for the whole crop season, i.e., from five to eight months and, therefore, constitutes the sole crop of the year wherever it is cultivated, although many other crops can be and are grown admixed with it.

Castor is believed to have had its origin in India and North Africa, and is now grown in many parts of the world. Brazil, which is the largest producer of castor seed, contributes about 39.0 per cent to the world production of castor seed. India is the second largest producer of castor seed with about 26.6 per cent of the world production. British East Africa, Thailand and U.S.A. are the other important producers of castor seed.

CULTIVATION

In India, castor crop is sown both in the kharif and in the rabi seasons. The kharif crop is sown between May and July, and harvested in January and February. The rabi crop is sown between September and November, and harvested in March and April.

It is mainly grown in Andhra Pradesh, which accounts for 65 per cent of the area sown. Maharashtra, Mysore, Madras and Orissa are the other important producing States. The total area

under castor seed varies from 1.3 to 1.5 million acres, and production from 1 to 1.3 lakh tons. The yield per acre varies from 165 to 199 lb.

Agronomic experiments have shown that a spacing of 3 ft. either way is the optimum, and that the best yields are obtained when the heads are harvested at full maturity and dried immediately after harvest, instead of curing them in stacks for some time.

IMPROVED STRAINS

State	Strain	Special features	Average acre yield (in lb.)	Seed source
Andhra Pradesh	HC 6	Red with double bloom, spiny, loosely set on the spike, small seeded like local, high yielder in seed and oil.	350	Director of Agriculture, Andhra Pradesh, Hyderabad.
Madras	TMV. 1	Fairly resistant to semi-looper pest; plants are short (4' to 6') ; capsules compact, inflorescence 1' to 2'; high yielding, short duration variety.	750	Director of Agriculture, Chepauk, Madras.
	TMV. 2	Plants are of medium height; inflorescence 2' to 3'; capsules sparsely set, a high, yielding medium, duration strain	755	-do-
	TMV. 3	A high yielding long duration strain; best suited for growing as a border	750	-do-

crop, seeds contain more oil than other varieties.

CO-1 Perennial castor, high yielding with high oil content. 4~81b. per-do- tree per year

Maharashtra	5-20 Small seeded, 15 to 20 per cent higher yield, early variety.	875	Director of Agriculture, Maharashtra, Poona.
Mysore	M.C.-1 Suited for inter-cropping with ragi.	300	Director of Agriculture, Mysore, Bangalore., -do-
	Rosy Does well on black cotton soil.	350	
Madhya Pradesh	EB-16 High yielding, high oil content, bold seeded.	388	Director of Agriculture, Madhya Pradesh, Rewa.
Uttar Pradesh	T. 3 High yielding, compact spikes.	1,000	Director of Agriculture, Uttar Pradesh, Lucknow.

CHAPTER 20

NIGER AND SAFFLOWER

INDIA IS the second largest producer of niger seed in the world, and has an area of roughly over eight lakh acres under the crop with an annual estimated production of about 70,000 tons. It is chiefly cultivated in Madhya Pradesh, Maharashtra, Andhra Pradesh and Orissa. The oil is edible, and is also used in the manufacture of soaps, and for lubrication and lighting purposes. The oilcake is a rich concentrate for milch cattle, but is rarely used as manure. The crop thrives well in lateritic and light loamy soils, and is generally raised as mixtures with pulses and other kharif crops from July-August to November-December.

IMPROVED STRAINS OF NIGER

State	Strain	Special features	Average acre yield (in lb.)	Seed source
Maharashtra	Niger B	High yield and high oil content.	300-400	Director of Agriculture, Maharashtra, Poona
	No. 5	Early ripening.	222	-do-

SAFFLOWER

Safflower is largely cultivated in the States of Andhra Pradesh, Maharashtra, Madhya Pradesh and Mysore. Periodical estimates for area and production of this seed are not available. According to some rough estimates the annual production of the crop is estimated at about 1'3 lakh tons.

IMPROVED STRAINS OF SAFFLOWER

State	Strain	Special features	Average acre yield (in lb.)	Seed source
Maharashtra	Safflower Oil No. 630	superior drying quality, suitable for Nasik and Ahmednagar districts.	in 120	Director of Agriculture, Maharashtra, Poona.
	No. 7	Spiny and white flowered, suitable for Nagpur tract.	650	-do-

CHAPTER 21

SESAMUM

SESAMUM, til or gingelli, is an oilseed that furnishes one of the most important oils for domestic consumption in Indian households, especially in South India. The oil is used for cooking, and for toilet purposes. The lower grades of the oil are used for soap making. In Europe, the gingelli oil is used for adulterating olive oil as a salad oil. The seed is also used directly as a human food. The oilcake is edible, and mixed with sugar is eaten by the working classes. It is, however, as cattle feed that it finds its greatest use.

Gingelli is the oldest oilseed of the world and is said to be native to India, though its origin is sometimes traced to Africa and sometimes to the East Indies. All the same, India is the largest producer of sesamum seed followed by China. The other important sesamum-producing countries are the Sudan, Mexico, and Turkey.

CULTIVATION

In India; the crop is sown both in the kharif and rabi seasons. The kharif crop is sown between May and August, and harvested between August and December. The rabi crop is sown in January and February, and harvested between May and July. Its cultivation is concentrated mainly in Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra, Andhra Pradesh and Madras which together account for about 89 per cent of the total area sown. The area under the crop is about 5.3 million acres, and total production is about 3~6 lakh tons. The yield per acre varies from 154 to 205 lb.

The crop has a wide range of cultivation both in the tropical and the sub-tropical areas. It is cultivated in the plains as well as on elevations up to 4,000 feet during the warmer part of the year at temperatures of 70° F and above. It is grown solely as a rain-fed crop in tracts where rainfall in the crop season is not below 20 inches. It takes three to four months or a little

longer to grow; and if sown in the early season it is followed by another crop, such as horse-gram, jowar, coriander, wheat, or cotton in the same year. It can be sown late also, in which case it is preceded by- an early season crop of ragi, fodder, jowar or black-gram. When sown in the middle of the year, it forms the only crop of the year. It is grown both as a pure crop and in conjunction with arhar, castor, etc.

Intensive inter-specific hybridization and cytological investigations have been in progress at the Indian Agricultural Research Institute, New Delhi, for evolving strains resistant to pests and diseases.

IMPROVED STRAINS

State	Strain	Special features	Average acre yield (in lb.)	Seed source
Madras	TMV. 1 (rain-fed)	Suitable for all seasons, cent increase in yield over the local.	300	Director of Agriculture, Chepauk, Madras-5.
	TMV. 1 (irrigated)	-do-	500	-do-
	TMV. 2	Suitable for cold weather cropping, t per cent more oil, matures about a week earlier than the local variety.	375	-do-
	TMV. 3	Suitable for summer season under irrigated conditions, fairly resistant to shoot webber attack.	500	-do-

Maharashtra	NO. 85	Higher in yield and 340 oil content, bolder and more white than local.	Director of Agriculture, Maharashtra, Poona.
	No. 128	High yielding strain 145 under Nagpur conditions.	Director of Agriculture, Madhya Pradesh, Rewa.
Uttar Pradesh	T. 10	High yielder, early 500-maturing.	Director of Agriculture, Uttar Pradesh, Lucknow.

CHAPTER 22

RAPE AND MUSTARD

THE term rape and mustard is used to cover three more or less similar oilseeds of the crucifer family, viz., colza (sarson), rapeseed (toria), and mustard (rye). In India, another somewhat similar oilseed called taramira is also included in this group. These oilseeds furnish important oil for consumption in Indian homes, especially in Uttar Pradesh, Bihar, West Bengal and Assam. The oilseed is used for human consumption, as cattle feed, and for toilet purposes. It is, however, as a source of oil, that it finds its largest use in India. The oilcake is utilized as a cattle feed, and to some extent as a manure. Apart from home consumption, the oilseed, oil and the cake form items of export. In foreign countries; rape oil is used chiefly as a lubricant after refinement, and as blown rape oil. It is also used for quenching steel plates. Small quantities are used for purposes of lighting and for the manufacture of soft soap.

India is the largest producer of rapeseed and mustard in the world, contributing nearly 31 per cent to the total world production. Other important rapeseed- and mustard-producing countries are: China (23.7 per cent), Pakistan (10.1 per cent) and Japan (9.1 per cent).

It is mainly grown in Uttar Pradesh, Punjab, Rajasthan, Assam, Madhya Pradesh and West Bengal which together account for 92.4 per cent of the total area under it in India. Other important rapeseed and mustard producing States are Bihar, Orissa and Maharashtra. The area under the crop and its production are 6~ 1 million acres and nine lakh tons, respectively. The yield per acre during 1957-58 was estimated at 335 lb.

IMPTOBRF STRAINS OF RAPE AND MUSTARD

State	Strain	Special features-	Average Seed source acre yield (in lb.)
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Uttar Pradesh	Brassica campestris (Var. Yellow Sarsan) T. 151	Bold seeded, suitable for sowing mixed with wheat because of tall growth and compact branching.	800-1,000	Director of Agriculture, Uttar Pradesh, Lucknow.
	Brassica juncea Var. Rai (Rai Laha) Rai RT-II. Laha 101	Suitable for rich soils. or Tall branching, suitable for mixed sowing.	800-2,000	-do-
State	Strain	Special features	Average acre yield (in lb.)	Seed source
Punjab	Brassica juncea (Rai) L. 18	Heavy yielder, resistant to aphids.	1,400	Director of Agriculture, Punjab, Chandigarh.
West Bengal	Brassica campestris Var. Toria, (Tori). Tori No. P54	Better yielder.	560	Director of Agriculture, West Bengal, Calcutta.
	Brassica juncea (Rai) Rai No. P-85	High yield and oil content.	620	-do-
Assam	Brassica campestris M.27	High yield and oil content.	860	Director of Agriculture; Assam,

Bihar Brassica
jtn-
cea (Rai)
BR. 40

High yield and oil . .
content, early
variety.

Shillong.
Director of
Agri-
culture,
Bihar,
Patna.

CHAPTER 23

LINSEED

Tai linseed plant furnishes two important products: the oilseed-yielding linseed oil, and flax. The linseed oil, which dries readily, is extensively used in painting and varnishing. The oilcake is the most valuable cattle feed in Europe. The flax got from the crop serves as fibre for the manufacture of linen. It is, however, in cold countries that high grade fibre is obtained. Under Indian conditions, a sufficiently satisfactory yield per acre of flax of good quality has not been obtained, and the crop has not, therefore, been cultivated to any extent for the sake of the fibre. However, experiments conducted in northern India have demonstrated the possibility of profitable cultivation of linseed for flax also.

The Indian production of linseed is quite large, and its exports form a considerable proportion of the quantity imported into Europe. India contributes nearly 11.7 per cent of the total linseed production of the world. The other important producing countries are : U.S.A. (30.9 per cent), U.S.S.R. (13.2 per cent), Argentina (14.8 per cent), and Canada (1.5 ~ 1 per cent). '

CULTIVATION

The linseed crop is generally confined to sea level areas or low elevations and the plains, as distinct from hilly tracts. As a seed crop, it can be cultivated even up to a level of 2,500 feet, although the possibility of its cultivation as a fibre crop also at this elevation is not ruled out. The crop is suited to tracts of low rainfall. It cannot stand much rain in the growing period: It is grown either as a single crop of the year, or is preceded by one of the early season crops usual on the black cotton soil, such as black or green-gram, coriander, short-season groundnut, etc., which are harvested by the end of August. The crop is grown both pure and mixed. More generally, however, the crop forms, when sown mixed, the only crop of the year.

In India, the crop is sown between August and November, and harvested between January and April. It is mainly grown in Madhya Pradesh, Uttar Pradesh, Maharashtra, Bihar, and Rajasthan which together account for about 89 per cent of the total area sown to this crop. Mysore and Andhra Pradesh are the other important linseed-producing States. The total area under linseed is now 3~4 million acres, and total annual production is about 3'7 lakh tons. The yield per acre varies from 215 to 255 lb.

IMPROVED STRAINS

State	Strain	Special features	Average acre yield (in lb.)	Seed source
Maharashtra	Linseed No. 3	Good yielder, early ripening.	403	Director of Agri- culture, Maha- rashtra, Poona.
	No. 55	Good yielder.	379	-do-
	Malsiras No. 10	Superior in drying qualities, 20 per cent more yield.	430	-do_-
	Sholapur No. 36	Bold seeded.	400	-do-
Uttar Pradesh	T. 1	A bold seeded, early, high-yielding and rust-resistant strain, suitable for-Bundellchand only.	1,200	Director of Agri- culture, Uttar Pradesh, Luck- now.
Punjab	K. 2	Bold seeded, tall, white flower, rust and wilt-resistant, high-yielding	750	Director of Agri- culture, Punjab,

Bihar	B.R. I	strain. Dual-purpose variety, yields ' excel- lent type of linen fibre.	445	Chandigarh. Director of Agri- culture, Bihar, Patna.
West Bengal	WB. 37	Dual-purpose strain, yielding fibre and seed of high oil content.	480	Director of Agri- culture, West Bengal, Calcutta.

CHAPTER 24

COTTON

COTTON has the distinction of being the most extensively cultivated commercial crop of the world. Besides its chief use as fibre for cloth, it finds extensive employment in daily life in diverse ways. The seed, which in weight is nearly two times the cotton lint, also has a wide range of uses. Its outer fluff or fuzz is used for felting, stuffing and manufacture of cellulose, producing acetate rayon yarn and other cellulose products; the shell or hull serves as food for cattle; and the meat or kernel inside is pressed into oil which when refined yields high grade cooking oil which is also processed into vegetable ghee. The oilcake is used as cattle feed.

From remote antiquity, three principal countries of the East have been known for their distinctive fabrics: China for silk, Egypt for flax, and India for cotton fabrics. The cultivation of cotton and its manufacture into textiles have been practised in India since pre-historic times. The most ancient cotton fabrics known to the world are the fragments of a material discovered in the excavations at Mohen-jo-Daro in Sind (now in Pakistan), which are believed to be about 5,000 years old, and have been identified as belonging to the present desi cotton of northern India.

The sacred institutes of Manu dating from 8,00 B.C., the testimony of Herodotus that 'India had wild trees that bore fleeces as their fruit and of these Indians made their clothes', the Greek fable of a vegetable lamb or an animal growing on a tree, the complaint of the Roman historian Pliny that 'every year India was draining the Roman Empire of 100 million sesterces', the observation of Marco Polo in the 13th century that 'Masulipattam produces the finest and the most beautiful cottons to be found in any part of the world', and the reference to the superfine muslin manufactured in Dacca in East Bengal as 'webs of woven wind'-all constitute further evidence of the widespread cultivation of cotton and manufacture of cotton textiles in India since very ancient times. They also indicate the excellence of

Indian craftsmen of those days in the art of cotton spinning and weaving.

CULTIVATION

Cotton is essentially a tropical crop, but its cultivation is carried on successfully over many parts of the world, far removed from the tropics. The limits of cultivation may be said to be the 40th latitude on both sides of the equator. It is grown either at sea level or at moderate elevations not

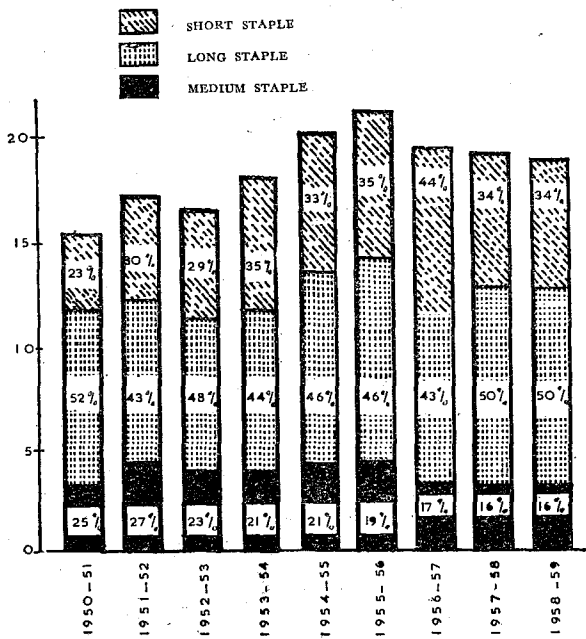


FIG. 18. Area under cotton (million acres)

exceeding 3,000 feet. Cultivation is confined largely to flat open country and rough hilly tracts, where the minimum temperature does not fall below 70° F. Higher temperatures are very favourable, and the upper limit may go up even to 105°F. in the picking season. The crop cannot stand other than moderate rainfall. Rainfall exceeding 35 inches should be considered harmful to the crop. The lower limit for a purely rain-fed crop is

20 inches. On black cotton soils, hardly any rainfall is needed over most of the growing period, provided good showers have been received before the crop was sown and a satisfactory start has been made. It is grown both as a dry crop and as an irrigated crop. If the rainfall is distributed over both the monsoons, the extraordinary fertility of the black cotton soil allows a wide variety of crops to be grown, and also taking of two crops in the year—one in the North-East Monsoon period, and the other in the Southwest Monsoon period. If, on the other hand, the rainfall is low and is confined to the North-East Monsoon period, then only one crop is grown in the year. There is considerable mixed cropping practice with cotton. Cereals like rice, ragi, jowar and bajra, pulses such as tur, black-gram, green-gram, and horse-gram, and other crops, e.g., gingelli, groundnut and castor, enter into the mixture. In certain tracts, a mixture of local and American cotton is also reported. The 'New World' cottons are, however, grown pure—whether as dry crops or as irrigated crops.

The quality of cotton depends on the length of its staple, which provides the basis for classification into short staple, medium staple, a long staple categories. The greater the staple length, the more suited is the cotton for the production of finer yarns. Cotton with a staple of 11 / 16 and less is classed as short staple, that with a staple of less than 7/8" longer than 11 / 16" is termed medium, and that with 7 / 8" staple length a above is called long staple.

India contributes nearly 9~4 per cent of the total production of cot in the world. The other important producing countries are: U.S (25.8 per cent), China (19.5 per cent), U.S.S.R. (15.3 per cent), Mexico (5.3 per cent), Egypt (4.6 per cent), Brazil (3.1 per cent), Pakis (2.9 per cent), Turkey (1.9 per cent), Sudan (1.3 per cent), and P (1.1 per cent).

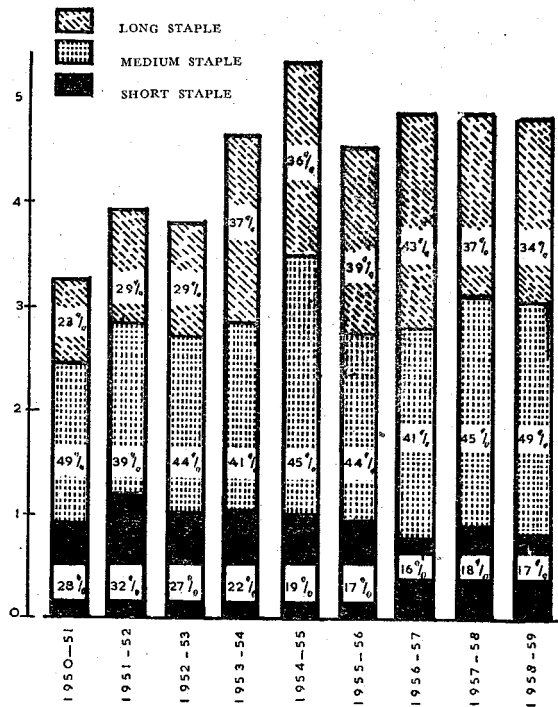


FIG. 19. Production of cotton (million bales of 392 lb. each)

In India, cotton is sown between March and August, and harvest between September and April. It is grown mainly in Andhra Pradesh, Maharashtra, Madhya Pradesh, the Punjab, Madras and Mysore, which together account for more than 90 per cent of the total area sown. And Pradesh, Uttar Pradesh, and Rajasthan are the other important producing States.. The total area under cotton is about 19'8 million acres, out of

FIG. 20. Area under improved varieties (million acres)

which 3.2 million acres (16 per cent) are under short staple, 9.9 million acres (50 per cent) are under medium staple, 6.7 million acres (34 per cent) are under long staple. Production of cotton (lint) is of the order of 4.7 million bales of 392 lb. each, of which the short staple constitutes 0.8 million bales or 17 per cent, the medium staple 1.3 million bales or 49 per cent and the long staple 1.6 million bales or 34 per cent.

The total area and production of cotton as shared by important cotton-growing States during 1958-59 are given below:

State	Area (thousand acres)	Production (thousand bales of 392 lb. each)
Bombay	10,915	2,481
Madhya Pradesh ..	1,926	397
Mysore	2,512	425
Punjab	1,485	711
Andhra Pradesh	945	132
Madras	1,123	356
Rajasthan	620	147
Uttar Pradesh	196	34
Other States	102	12
- _ - - - - Total	19,825	4,705

The average yield per acre of cotton lint varies from 50 to 220 lb. In 1958-59, it was estimated at 99 lb.

IMPROVED VARIETIES

Botanically, the cotton varieties of India belong to four distinct species, namely, *Gossypium arboreum*, *G. herbaceum*, *G. hirsutum* and *G. barbadense*. Of these, *G. arboreum* is supposed to be indigenous to India, and fragments of yarn found in the excavations at Mohen-jo-Daro (Sind, Pakistan) have been identified as belonging to this species. The second species, *G. herbaceum*, seems to have been introduced in India from the Middle-East countries. The history of introduction of *G. hirsutum* in India can be traced back to the early days of the British East India Company. The last species, *G. barbadense* has recently been introduced from the West Indies.

The *arboreum* group includes varieties which are predominantly coarse and short-stapled, though a few among them are medium-stapled and fairly fine. They are cultivated to varying extent in almost all cotton-growing States.

The varieties belonging to the *herbaceum* group are generally much finer and longer in staple than the *arboreum* varieties. Their cultivation is confined to parts of Maharashtra, Andhra Pradesh and Mysore.

The *hirsutum* group includes varieties which are medium to longstapled, and are much finer than those of the other two groups. These varieties are largely grown in the Punjab, western Uttar Pradesh, the Bikaner Division of Rajasthan, and parts of Madhya Pradesh, Mysore, Andhra Pradesh, Madras and Maharashtra. The *barbadense* type is grown on a small scale in Kerala and Mysore.

For purposes of trade, the cotton varieties of India have been classified into 14 groups according to the staple length and region of cultivation. The commonly known trade varieties according to this classification and their tracts of cultivation are as follows

Trade varieties	Tracts of growth
Bengals . .	Punjab, Uttar Pradesh and Rajasthan.
Punjab	Punjab, Uttar Pradesh and Rajasthan.
Americans	
Oomras . .	Madhya Pradesh, Khandesh, Deccan Vidarbha and Aurangabad Division of Maharashtra.

Gaorani . .	Aurangabad Division of Maharashtra.
Central India	Madhya Bharat region of Madhya Pradesh.
. .	
Broach . .	Broach, Baroda, Kaira, Panchmahals, Ahmedabad and Sabarkantha districts of Gujarat.
Surd	Surat and Broach districts of Gujarat.
Dholleras . .	North-west Gujarat.
Trade varieties	Tracts of growth
Jayadhar.	Mysore
Southerns . .	Mysore and Andhra Pradesh.
Tinnevellis . .	Coimbatore, Madurai; Ramanathapuram and Tirunelveli districts of Madras.
Cambodias . .	Coimbatore, Salem, Tiruchirapalli, Madurai, Ramanathapuram, and Tirunelveli districts of Madras and Palghat district of Kerala.
Laxmi. . .	Andhra Pradesh, and Mysore. '
Madras	— Madurai, Ramanathapuram, Salem,
Uganda ..	Coimbatore, Tirunelveli; Chingleput and South Arcot districts of Madras.
Salems . .	Coimbatore and Tiruchirapalli districts of Madras.
Comillas ..	Hill tracts of Assam and Tripura.
Indo-American MAS	Gujarat Deccan Canals area of Maharashtra and Belgaum district of Mysore.

With a view to evolving high-yielding, high-ginning and better quality types, cultivation of which is more remunerative to the grower, a vast amount of crop improvement work has been done in this country during the last 35 years under the auspices of the Indian Central Cotton Committee. Already, a number of improved types of arboreum, herbaceum and American varieties to suit different climatic conditions and tracts, have been

evolved. The important improved types which are being recommended for cultivation in different States are as follows:

Variety	Botanical name	Tract in which it is grown	Staple length (in 32nd inch)	Ginning percentage	Average mill spinning capacity
Punjab	-				
320F	G. hirsutuna	Sub-montane tract	28--30	34	32
2318	G. arboreurra	-do--	20	43	6
H. 14	G. hirsutum	Haryana tract	30	35	32
LL. 54	-do-	Ferozepur district	34	36	48
Uttar Pradesh					
35J1	G. arboreuin	Whole State	26	37	16
216E	G. hirsuturn	Western and Central districts	28-30	33	32
Rajasthan					
Ganganagar 1	C. drboreum	Ganganagar tract	20	40	8--11
Indore-1	G. hirsuturra	Mewar tract	26-28	30	20
Variety	Botanical name	Tract which it is grown	Staple length (in 32nd inch)	Ginning percentage	Average mill spinning capacity
Madhya Pradesh					
Indore 2	G. hirsutum	Indore tract	26-28	31	26-28

A. 51.-9	G. hirsutum	W tract	Nimar 28	35	34
Majari	G. arboreum,	Nimar tract	26	36	30
Maharashtra and Kalyan	G. herbaceum	North Gujarat	26-27	39-40	,20
134-Co: 2-M	G. hirsutum	-do-	34--38	34-36	36-38
CJ 73 (Sanjay)	G. arboreum	Saurashtra-Kutch	28-30	34	27
halyan	G. herbaceum	-do-	26-27	39-40	20
Digvijay	G. laevis	Middle Gujarat	29	39	32
170-Co.2	G. laevis	-do-	32-36	36-38	36-38
2087 (Vijalpa)	G. laevis	South Gujarat	28-32	36-37	26-30
Virnar	G. arboreum	Khandesh	2G-28	38-39	20-2=1
H. 420	G. arboreum	Vidarbha	28	33-34	20-21
Buri0394	G. hirsutum	-do-	28-30	32-34	28 -
No. 91	G. arboreum	-do-	25-27	35-36	26-31
M. (Malini)	G. arboreum	-do-	25-27	3	24-30
Gaorani 12	G. arboreum	Marathwada tract	28-30	31	26-28
2204 (Daulat)	G. arboreum	-do-	28	36	30-32
Gaorani 6	G.	-do-	28-30	32	26-28

	arboreum				
Andhra Pradesh					
Parbhani-American	G. hirsutzztn	Telengana	28	32-33	24-28
Ivesterns-1	G. herbaceztn	Rayalaseema	26	28	21
Cocanadas-2	G. arboretztn	Circars	24-26	30	18-22
N. 14	G. arboretum	Rayalaseema	28-30	25	32
M».sore Slate					
Jayadhar	G. lar;tbaceu	Raichur, Bijapur-Dharwar	28-29	29-31	30
La:mrii	C. hirsulztnz	Bijapur-Dharwar	29-30	36	32
Westerns-1	G. herbacertoz	--do-	26	28	24
M.A. 5	G. lairsuttttn	M.A.'s tract	33-34	35	32
Sel. 69	G. herbaceu ztz	-do-	24-26	30	20
Madras G18G-9 K. (Pandyan) 1\ICU-2	C. G- arborettn	Tinnies (Southern districts)	`30	33	33
	G. hirsutum	liarunganni (Ccn-tral districts)	32-35	32	3G-38
		Summer Cambodia (coastal and			

9030-G	G. hirsutunt	southern districts) Winter Cambodia (Central districts)	32-34	38	4-2
Kerala and Nlysore					
Andrews	G. barbadeu se	Coastal and up ghat areas	40	33	GO

The Indian Central Cotton Committee, in collaboration with the State Governments, is financing a number of seed multiplication and distribution schemes in various parts of the country to-help make available to cotton growers pure seeds of these improved varieties. The distribution of pure seed of these types is also being vigoroulsy carried out under the special Cotton Extension Scheme of the Government of India since 1950-51. Though -substantial progress in extending their cultivation has already been made, the area covered so far by the improved types farms only 70 per cent of the total area under the cotton crop in the country. There is thus considerable scope for further expansion of the improved varieties. In this connection a coordinated scheme for multiplication and distribution of cotton seed has been recommended by the Committee so that the whole tract is covered in five to six years by improved varieties of 1.5 lakh acres each ensuring purity.

CHAPTER 25

JUTE

JUTE is one of the most important commercial fibre crops of the world, and particularly of India. The fibre is obtained from two distinct species, *Corchorus capsularis* and *C. olitorius*, the former producing the white fibre and the latter, the tossa fibre of commerce. The cultivation of jute is confined mostly to India and Pakistan, contributing, on an average, nearly 38 per cent and 52 per cent, respectively, of the total world jute production. Pakistan is a heavy exporter of raw jute, while India leads in the export of the manufactured materials. The history of the cultivation of jute in India and of the development of its manufacture is remarkable in that the crop has risen within less than a century from a humble position to one of leading importance among the industrial crops of the world. Jute is extensively used for the manufacture of packing clothes, hessian and bags.

CULTIVATION

In India, the crop is sown between March and May, and harvested between July and September. It is grown mainly in West Bengal, Bihar and Assam, which together account for about 90 per cent of the total area sown. Orissa, Uttar Pradesh and Tripura are the other States, which contribute the remaining ten per cent area. The total area under it and the annual production are (1955-56) 1·6 million acres and 4·1 million bales of 400 lb. each, respectively, shared by the important jute-growing States as follows

State	Area (thousand acres)	Production (thousand bales of 400 lb. each)
West Bengal	876	2,596
Bihar	455	1,216

Assam . . .	323	989
Other States	173	377
Total ..	1,827	5,178

The average yield per acre varies from 900 to 1,140 lb. In 1958-59 it was estimated at 1,134 lb.

IMPROVED STRAINS

Corchorus Capsularis Strains

Strain ARC-212. This is a strain evolved by the Jute Agricultural Research Institute. It matures about the same time as the strain D-154, which is the standard capsularis strain, and yields about 11 per cent higher. The quality of its fibre is considered to be very good. It is a full green type. Among capsularis strains this is at present the highest yielder.

Strain D-154. This is a late strain evolved in 1919 by the Bengal Agriculture Department. It is a green coppery red type and gives high yield.

Strain ,ERG-321. This is an early quick growing type, evolved by the ,Jute Agricultural Research Institute. It matures about three weeks earlier and yields slightly less than D-154, but its yield is as good as that of D-154 under low land conditions. It is a coppery red type with stem coloured uniformly coppery red except at the tip where it is green. The fibre is of very good quality. This strain is very suitable for double cropped (jute-paddy) areas; and flooded regions where early harvest is desired.

C. olitorius Strains

Strain SRO-632. This is a high yielding, sparsely -branched, full green type, evolved by the Jute Agricultural Research Institute. Though it takes only about ten days more than the strain C.G., the standard olitorius strain to mature, on the average it yields about 30 per cent higher and gives fibre of good quality.

Strain ,SRO-753. This also is a full green strain evolved by the Jute Agricultural Research Institute. It is similar in appearance to JRO-632, and also more or less similar in yield.

Strain ,SRO-620. This is a light red type evolved by the Jute Agricultural Research Institute. It matures about the same time as C. G. does, but yields about 20 per cent higher, giving fibre of the best quality among the cultivated olitorius types.

CHAPTER 26

MESTA

MFSTA fibre of commerce is obtained from two species, viz., *Hibiscus cannabiraus* and *H. sabdariffa*. In different parts of India, *H. cannabinus* goes by different names, viz., Ambadi and Bombay hemp in Maharashtra, gogu or Bimli in Andhra Pradesh, Channa in Bihar, Deccan hemp and Kasigogu in Andhra Pradesh, and *H. sabdariffa* as Mesta in West Bengal, Channi, or Przsa hemp in Bihar, etc., Outside India, *H. cannabinus* is known as Kenaf and *H. sabdariffa* as Roselle.

It has now been established that the nearest approach to jute fibre is mesta. During World War II, the normal supply of jute could not cope with the enormous demand for it, and the need was felt for finding substitutes. That proved to be the first major stimulus for the development of mesta. Its cultivation has since expanded rapidly, and it has assumed great commercial importance. It is being cultivated in many parts of the world, particularly, in the U.S.A., Cuba and South Africa..

In India, the total area under, mesta is about 851 lakh acres, yielding 1 ~58 million bales of 400 lb. each. The main growing States are West Bengal, Bihar, Maharashtra and Andhra Pradesh which, together, account for about 8~7 per cent of the total production. The other States in which it is cultivated are Assam, Tripura, Madhya Pradesh, Madras, Mysore, Orissa and the Punjab. The acreage and production figures -for 1958-59 are given below:

State	Area (thousand acres)	Production (thousand bales of 400 lb. each)
Andhra Pradesh ~	78	158
Assam :	7	14
Bihar	116	201
Bombay	163	163

Madhya Pradesh	22	18
Madras	1	2
Mysore	56	56
Orissa	15	31
Punjab	1	2
	-	
West Bengal	362	61
Tripura	30	75
Total ..	851	1,58T



FIG. 21. *Mesta* crop

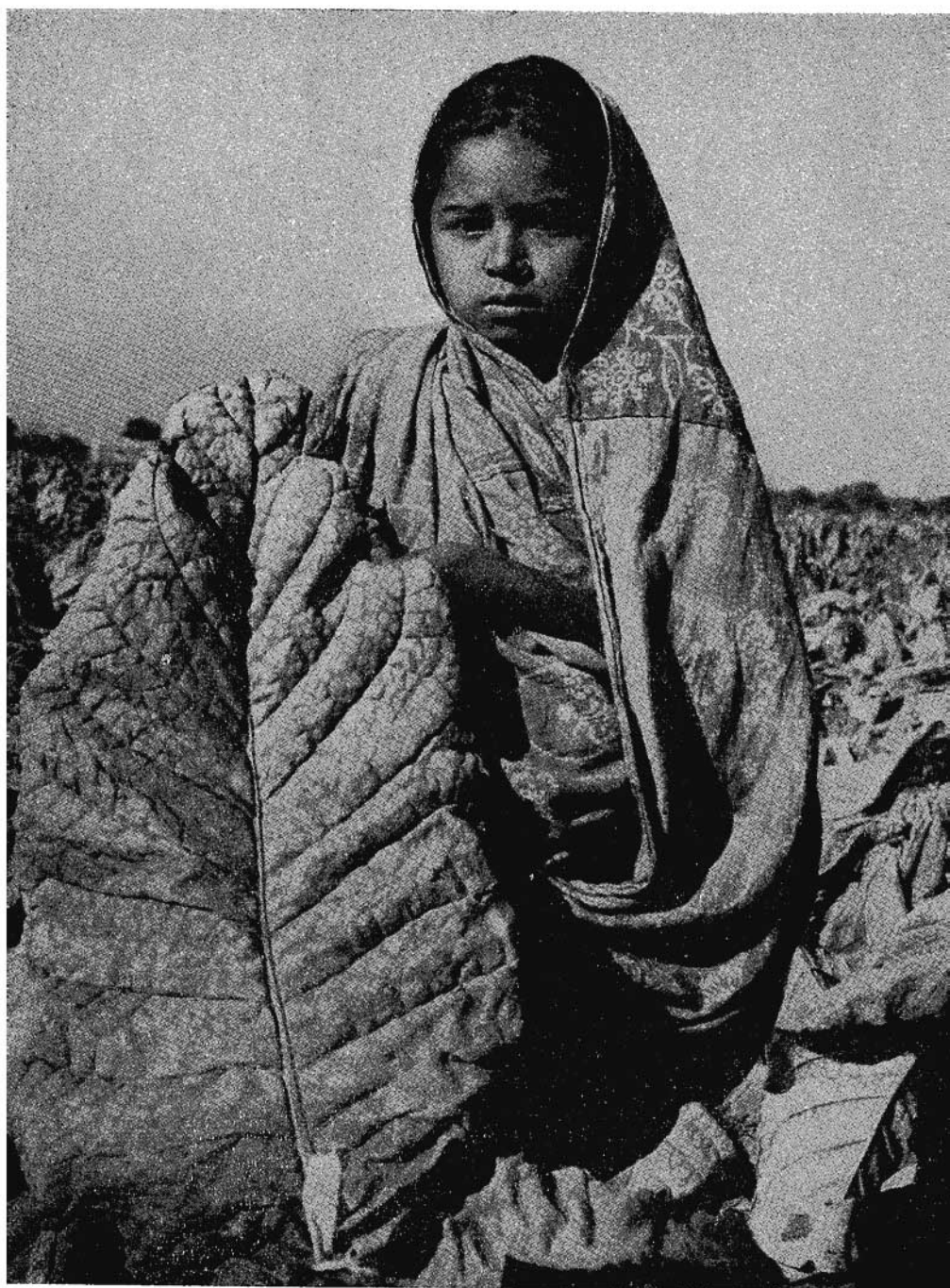


FIG. 22. Tobacco in the field



FIG. 23. Betel vine



FIG. 24. Lemon-grass

The yield per acre varies from 350. ~to 1,250 lb., . though in Cuba as high a production as 2,400 lb. has been obtained.

Under Indian conditions, it is a somewhat poor yielder compared to jute.

CULTIVATION

Mesta is generally grown on lands not quite suitable for jute. Unlike the latter, it can thrive well even in drier areas. The plant grows to a height of 8 to 12 ft. in about 100 to 180 days, after which it is harvested.

It is grown as a single crop in Andhra Pradesh, Orissa, Bihar and West Bengal. However, in other States it is generally grown as a mixed crop along with millets, pulses, cotton, paddy, etc.

Mesta is retted in water for extracting the fibre almost in the same way as jute is retted, but in some foreign countries mechanical extraction is generally employed. A comparative analysis of the physical characteristics of mesta and jute fibre is given below:

Characteristics	Jute (mean of 30 capsularis and 16 olitorius samples)	Mesta (mean of 3 capsularis samples)
Coarseness of fibre strands (micro-Gram/cm.) ..	97.2	137
Bundle breaking twist (t.p.i.)	4.18	4.15
Ballistic work of rupture of bundles (inch/lb.) (with t.p.i. 0 - 7) . .	39 .7	33..6
Apparent density (gm./cc.) . .	1.297	1.274
Torsional rigidity. of bundles (arbitrary units)	18 .60	18 .58
Coefficient of friction . ,	0 .50	0 .47.

Detailed studies have shown that except for lignin content . (mesta contains less lignin than jute) the average chemical composition of the two fibres is practically the same. As regards

spinning performance, mesta is somewhat inferior to jute, presumably due to its coarseness. Moreover, it gives a weaker yarn than jute. This, however, does not detract from its commercial importance, for, of all the substitutes for jute, it has been found to-be the best. Indian mills invariably use mesta along with jute both for hessian and sacking material.

CHAPTER 27

SUGARCANE

SUGARCANE is one of the most important cash crops of the world. It is essentially a tropical plant and hence, thrives well in tropical countries. There are, however, areas as in Louisiana, South Africa and North India in the sub-tropics where sugarcane is widely cultivated, although the climatic conditions are intrinsically unfavourable to the crop.

The important sugarcane-growing countries are: Cuba, India, Pakistan, Brazil, Australia, the Philippine Islands, Puerto Rico, Hawaiian Islands, Mexico, Dominican Republic, Indonesia, Taiwan, Mauritius, Peru, Argentina, South Africa, British West Indies and the U.S.A. India occupies a very important position, being one of the largest sugar-producing countries. Sugarcane products were first manufactured in India and there is some evidence that certain kinds of cultivated sugarcane arose in India.

The sugar industry is now the second largest industry in India. Sugarcane is grown in almost all the States. It is, however, concentrated in the North-the States of U.P., the Punjab and Bihar contributing more than 80 per cent of the total production. The area under sugarcane fluctuated between 4 and 4~5 million acres during the past decade, but has now risen to about five million acres. The acreage under the crop and production in terms of gur or raw sugar in 1957-58 were as follows:

State	Area (thousand acres)	Production in terms of gm (thousand tons)
Andhra Pradesh -.	176	401
Assam	65	67
Bihar	376	318
Bombay ..	270	764
Kerala . . .	22	35

Madhya Pradesh ..	122	125
Madras	121	340
Mysore	133	321
Orissa	59	94

State	Area (thousand acres)	Production in terms of gur (thousand tons)
	494	074
Punjab .		
Rajasthan	83	71
Uttar Pradesh ..	3,017	3,054
West Bengal ..	58	85
*Jammu & Kashmir ..	3	1
Delhi	11	7
Himachal Pradesh ..	4	2
Tripura	7	8
total	5,021	6,367

*This is a non-reporting area for this estimate.

Sugar, as produced in India from sugarcane, is of three kinds, viz., 'Our', 'khaitdsari' and white sugar. About 51 per cent of the cane produced is converted into gur. About 30 per cent is used for the manufacture of white sugar, and the rest is utilised as seed material and for raw consumption.

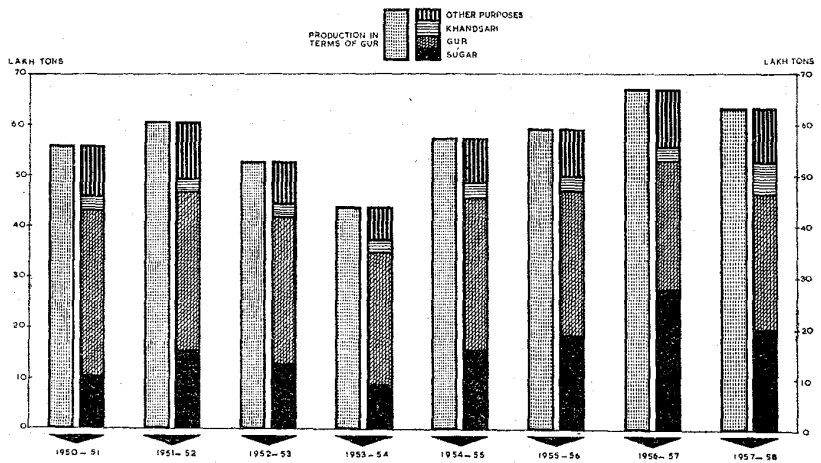


FIG. 25. Sugarcane production and utilisation

CULTIVATION

Sugarcane is a long duration crop, occupying the land for 12 months or more. Normally, in India it is a 10 to 12 month crop. In Maharashtra, the system of adsali planting prevails wherein the crop is harvested

when 16 to 18 months old. Severe cold and frost are highly detrimental to its growth. The best range of annual rainfall is 30 to 40 inches, though the cultivation of crop extends over areas receiving an annual rainfall of 25 inches to over 100 inches.

Sugarcane needs a well-drained medium loam soil which is neither too acidic nor too alkaline for optimum conditions of growth. In many areas sugarcane soils are dark, rich clay foams. They require provision of good drainage. However, the cane grows luxuriantly in such soils and large yields are possible. The retention of moisture in them is also good and the crop can stand some delay in irrigation. Since sugarcane is a soil-exhausting crop, the need for maintaining the organic matter and nitrogen content in the soil at a high level should be borne in mind. The soil should be enriched with farmyard manure, compost or bulky organic manures. Sugarcane should be grown minimum on a three-year rotation. Green manuring has given beneficial results. Sanai (*Crotalaria juncea*) and dhabacha (*Sesbania aculeata*) are considered to be the most suitable crops for green manuring.

Subject to variations necessitated by local conditions of rainfall, irrigation facilities, climate, etc., cane is planted from the middle of January to the end of March, i.e., from about the beginning of summer to the time of the vernal equinox. A second planting season, which is not so common, is about the time of the autumnal equinox. In the case of adsali planting in Maharashtra, cane is planted during the month of August. An important factor which decides when planting should be done is the date of onset of warm conditions that favour growth. Another consideration in planting is that the operation should be so timed that any possible risk of frost to the standing crop is avoided.

Two main systems of planting are followed-the flat and the trench. Pit system of planting is adopted in certain localised areas. In North India, the flat system of planting is mostly followed. Planting in deep trenches is the common feature in the southern States.

The soil for planting sugarcane is to be prepared carefully. It is necessary that it is in good tilth to a depth of six to nine inches to allow the buds to germinate and the roots to strike. The land is ploughed four to five times to reduce the soil to a fine tilth.

Sugarcane is propagated vegetatively. The unit of the cane for planting is a 'sett' consisting of three buds. The top portions of cane form excellent planting material. The optimum seed rate varies with the locality; but it is generally about 12,000 to 15,000 Betts per acre.

The inter-cultural operations for the sugarcane crop consist of weeding, hoeing and earthing-up of the crop. The main object of earthing-up is to suppress weeds and prevent the lodging of canes.

The yield of sugarcane depends largely on the variety of the cane planted, the method of cultivation adopted and judicious application of manure coupled with timely irrigations. The manuring and irrigational schedules vary with the tract. The manurial dose is generally from 200 to 300 lb. N in the southern States and from 100 to 150 lb. N in North India. A mixture of oilcake and ammonium sulphate has been found to be the best for sugarcane. The time of application varies with the tract.

The sugarcane crop needs a fairly large quantity of water during the periods when there is no rain. -The quantity of water

needed depends on the soil, and climatic factors, and thus varies from tract to tract. Frequent light irrigations seem to be better than heavy irrigations at long intervals.

The time of harvesting of cane is from December to April. Ordinarily, the age of the crop gives, a reliable index of the maturity of the cane. It is desirable to harvest the crop as early as possible after ripening, although the crop can stand in the field for about two months without appreciable loss in the sucrose content.

The average yield of sugarcane per acre in North India is 300 to 400 maunds, while in the South it is about 600 maunds. But yields as high as 2,500 and 1,500 maunds have been obtained with improved varieties in South and North India, respectively. A record yield of 122'4 tons per acre was obtained in Maharashtra State with the variety Co. 419.

VARIETIES

The indigenous ' sugarcane varieties have been classified into two species, viz., *S. barberi* and *S. Siizense*. The former species comprises four groups, viz., Saretha, Sunnabile, Mungo and ,Nargori, and the latter comprises the Pansahi group of Barber. More than one hundred varieties belonging to the above five groups were in cultivation in India before the advent of the improved hybrid varieties. These varieties were poor in yield and have now been completely replaced .by the improved varieties.

Canes belonging to the Saretlaa group were found in most parts of India. The more important varieties were Katha in the Punjab, Chin and Saretha in western U.P., Hullu Kabbu in Maharashtra and Gaizda Cheni in Mysore. The important varieties of the Sunnabile group were Dhaulu in the Punjab, :lfajora 'in Assam, Sunniabile in Maharashtra and Naanal in Madras: .A7ungo was .the important variety of the Mungo group which was being grown in Bihar. The varieties of the ,7Vargori group were in cultivation in Bihar, U.P. and Madhya Pradesh. The important representative of the Pansalai group was Uba.

The thick canes belonging to *Saccharum officinarum* sp. are mostly imported varieties. These are still grown in certain parts of the country for chewing purposes.

Breeding work was started in India in 1912 with the establishment of the Sugarcane Breeding Station (now Institute) at Coimbatore. The production of suitable seedling canes (Co. canes) has considerably benefited the cane growers and the Indian sugar industry. A succession of varieties is being sent out from the Institute. The very first hybrid variety to be adopted into cultivation was Co. 205 in the Punjab. Later Co. 213 became very popular in Bihar and U.P. These Co. canes replaced the indigenous canes and they in turn are being replaced by newly, evolved varieties. There has been an increase of about 50 per cent in yield over the indigenous varieties. The improved hybrid varieties now occupy over 90 per cent of the area under sugarcane in India. The more important of the varieties in commercial cultivation are:

Co. 312-A variety suitable both for the white sugar and the gur industries; heavy yielder and good ratooner; responds well to manures; gives gur of good quality; of late having proved susceptible to red rot, it is being gradually replaced.

Co. 419 A heavy yielding, vigorous variety with fairly good sucrose content; responds well to intensive cultivation and manuring; withstands water-logging; has a tendency to lodge; brittle when ripe and the stalk is liable to break; is somewhat susceptible to red rot and smut.

Co. X21-A vigorous grower giving good yield; a variety suitable to all types of soil; responds well to irrigation and manuring; moderate sucrose content; develops pits and is susceptible to wilt.

Go. 453-A heavy yielding variety; vigorous in growth and moderate in sucrose content; a variety suited to poor as well as rich conditions; is capable of growing under restricted water supply; has proved susceptible to red rot and is being replaced.

Co. 527--An early ripening variety with a satisfactory yield; needs a well-drained soil; responds well to manuring and irrigation; gur of good quality.

Co. 997-An early ripening variety with a good juice quality and moderately high yield; medium

thin canes, liable to lodge with heavy manuring; moderately susceptible to red rot.

Co.S. 109-A medium-ripening variety with a good capacity for tonnage; suitable for eastern U.P. areas.

Co.S. 510-A mid-early ripening variety with good tonnage and dependable performance.

B.O. 10-Variety bred at Pusa, Bihar; good yielder with a good quality of juice; comes up well in loamy soils, moderately resistant to red rot.

B.O. 11-An early ripening variety with good yield; responds well to manuring and irrigation; drought resistant; since it is proving susceptible to red rot, it is being replaced.

While the Sugarcane Breeding Institute at Coimbatore is meant for evolving improved sugarcane varieties for the various regions of India, there is a chain of Sugarcane Research Stations in the States for trial of the varieties under local conditions and for conducting agronomical, chemical; entomological and mycological studies. The Indian Institute of Sugarcane Research at Lucknow has recently been established for investigating fundamental problems of sugarcane cultivation, in India.

CHAPTER 28

TOBACCO

THE tobacco leaf after curing is used for smoking of as snuff, or chewed as a quid in many forms. Its cultivation belongs to comparatively recent times, having been introduced to the modern world by Spaniards from America. In India, its use and cultivation date from the arrival of the Portuguese in the beginning of the 17th century.

The tobacco industry in the country utilizes annually nearly 57 crone pounds of leaf, including the small quantity which is imported. This represents a value of nearly Rs. 49 crores, and yields an excise duty of about Rs. 26 crores. Government realises another Rs. 19 crores on the manufactured goods. Including the cost of raw tobacco, duty, manufacture and depreciation, the industry spends nearly Rs. 149 crores yearly. The total turnover for the various manufactured goods is estimated at nearly Rs. 194 crores, leaving the industry an annual net profit of about Rs. 45 crores. These estimates, although rough, give some idea of the importance of tobacco in the nation's economy.

India contributes nearly 7·3 per cent of the total tobacco production in the world. The other important producing countries are: the U.S.A. (27·8 per cent), China (16·7 per cent), the U.S.S.R. (7·1 per cent), Brazil (3·4 per cent), Japan (2·7 per cent), Turkey (2·6 per cent), Italy (2·3 per cent), Pakistan (2·0 per cent), Canada (1·9 per cent), Greece (1·8 per cent), France (1·5 per cent), Southern Rhodesia (1·4 per cent), Cuba and Mexico (1·1 per cent) each.

In India, the crop is grown mainly in Andhra Pradesh, Maharashtra and Mysore, which account for about 74 per cent of the total area sown. Assam, Bihar, Marinas, Uttar Pradesh and West Bengal are the other important tobacco-growing States.

The total area and production during 1956-57 were 10·3 lakh acres and 3·3 lakh tons respectively, shared by the important producing States. This is shown in the Table on page 169.

CULTIVATION

The average yield per acre during 1956-57 -was estimated at 640 lb. It generally varies from 600 to 750 lb.

Tobacco is grown under a wide range of conditions in the tropical, sub-tropical and temperate zones. Being a crop of only 3 to 4 month duration, its cultivation is possible even in the far northern and southern

State	Area (thousand acres)	Production (thousand tons)
Andhra Pradesh	. 390	144
Bihar	41	
Bombay . . . ,	24	71
Madras-	48	30
Mysore	135	24
Uttar Pradesh	46	17
West Bengal	40	11
Other Mates	83	24
Total ..	1,029	329

latitudes where summer lasts for this short period at least. The crop can be grown from sea level up to an altitude of 4,000 feet, under a temperature range of 60° F. to 105° F. When grown as a rain-fed crop, it requires only a moderate rainfall, about 20 inches of rainfall suffice if spread well over the growing period. It is not grown where the seasonal fall exceeds 4-0 inches. It is, therefore, not suitable for cultivation in the monsoon season in tracts of heavy rainfall. Heavy precipitation at the time when the leaves are maturing is detrimental to all types of tobacco. While in the case of cigarette tobacco, it may not be possible to flue-cure the leaf to the desired quality characteristics, in the case of other varieties the rain will wash away the gum and resin, which forms at that stage over the leaf surface and thereby reduce its quality. The seasons should conform to the requirements of curing also. Usually, bright rainless weather is required at the curing stage. Generally, a moderate-rainfall. in

the growing season followed by a dry spell, in which humidity does not fall below 80° F. is best for cultivation and curing. When the crop grows under irrigation, the quantity of minimum rainfall is not of much importance, but requirements as regards humidity at the curing time will have to be met. When grown as a rain-fed crop, it forms the only crop of the year, since the land has to be prepared in between the rainy weather periods for planting tobacco which is usually done in the months of September-October, after the heavy rains stop; and by the time it is harvested the season comes to an end and no other crop can be grown. However, when raised as an irrigated crop, it is followed by either irrigated Sorghum or irrigated ragi in the same year in the southern districts of Madras State and is followed by potato or maize in the Punjab. In certain tracts, where irrigation facilities are available, even two crops of tobacco are raised in the same year, one in the early part of the year from January to June, and the other in the later part of the year from October to March. However, generally speaking, the crop is sown between July and October, and harvested between February and May.

VARIETIES

There are about 60 valid species of tobacco, but only two, *Nicotiana glauca* and *Nicotiana glauca*, are cultivated extensively. By far the largest area in the world is under *glauca*. India grows both the species. Since *glauca* requires a cooler climate, it is mainly confined to the northern and north-eastern parts of the country, while *glauca* abounds all over the land. Varieties of *glauca* have usually pink flowers, and are known as desi types. Rustics varieties have yellow flowers, and are known as Irilayati and Kalkatia. Plants of *glauca* are tall and have long, broad leaves. Specific varieties for cigarettes, cigars and cheroots, bidi, hookah, chewing and snuff have been developed in this species. In contrast to it, rustics types are short and have round puckered leaves, and are grown only for hookah, chewing and snuff: They are usually not used in cigarettes, bidis or cigars. Some species of tobacco are used as garden plants, and have distinct horticultural varieties.

With the enormous increase in the demand for cigarettes in recent times, the demand for flue-cured tobacco varieties in

the *Nicotiana tabacum* species has swelled correspondingly. Its production has increased vastly in the U.S.A. and the countries within the British Empire, notably Rhodesia. In India also, its cultivation and appropriate curing are being taken up rapidly over large areas. The variety of tobacco grown and now considered most suitable is the Virginia or Yellow Tobacco known as 'Harrison's Special'.

Most of the cigarette tobacco area in India is concentrated in Andhra Pradesh, while in south Madras, cheroot and chewing tobaccos are extensively grown. In Andhra Pradesh, two well-known types Lanka and Natu, are also extensively grown for making hand-rolled cheroots or chuttas while the latter is also used in the manufacture of cheap cigarettes as well as pipe mixtures. North Bihar and West Bengal grow varieties of both the species for hookah and chewing. Bidi tobacco is almost entirely localized in the Charatar area of the former Bombay State and the Nipani zone of Mysore State. Uttar Pradesh and the Punjab have extensive areas under rustics and tabacum which are used mainly for the hookah, chewing and for snuff:

CHAPTER 29

BETEL

THE betel vine (Pier betel) has been known even from the times of the Mahabharata. The leaf is extensively used for chewing in India along with lime, betel nut (areca), several flavouring substances, and sometimes with tobacco. It is credited with digestive and medicinal properties, being fairly rich in vitamins B complex and G. The chlorophyll of the leaf is considered to be a good deodorant for the mouth and for the elimination of body odours.

CULTIVATION

The cultivation of betel vine is of a highly intensive nature and of a specialised character. The large requirements of labour and the high cost involved in establishing a betel vine garden and maintaining it, limits severely the area that could be managed by an individual farmer. The holdings of this crop are, therefore, generally small and rarely exceed half an acre at the most. The leaf can be retained on the vine even for as long a period as six months unlike other perishable cash crops such as vegetables whose produce has to be utilised as soon as it has matured on the plant. A betel vine garden can therefore prove highly remunerative if its cultural requirements are well understood and brought to bear upon its management.

The more important States which grow the betel vine on a commercial scale are Mysore, West Bengal, Madras, Maharashtra, Kerala, Andhra Pradesh and Assam which between them possess an area estimated at 58,500 acres under this crop.

The crop is grown at altitudes ranging from sea level to 3,000 feet above sea level. It favours cool situations under shade characterised by high humidity and provided with a continuous supply of adequate soil moisture. The plant demands well-drained and fertile soils for its best growth. It does not tolerate saline or alkaline conditions.

The betel vine belongs to the natural order Piperaceae. There are numerous varieties in cultivation in the States differing in their morphological characters and colour, texture and aroma of the leaf. The choice of a particular variety to grow depends largely on consumer preferences. The Bangla pan of Assam and West Bengal, the Lavangi of Andhra Pradesh, the Kali pan and Kapoori of Gujarat, the Kootakoti, Kalkodi, and Pudu kodi of Kerala of which large quantities are exported to North Indian markets and Pakistan, the Karpura kodi and Local of Madras, the Karibally, Kumbala batty and Ambadi of Mysore are some of the well known varieties of commerce.

Shade in the betel vine garden is provided by planting trees which also serve as standards for the vines to climb up. The most suitable species for this purpose are *Sesbania grandiflora*, *Erythrina indica*, *Moring apterygosperma*, and *Eriodendron acfructuosum*. They are raised by sowing seeds a few months prior to the planting of the betel vine cuttings. The sides of the garden are securely protected with tall close fencing trees that are thick enough to form an effective screen. In northern India, the gardens are practically covered over with a thatch of tall grasses, stalks of jute or dhaincha. In South India, the stalks of the tall *Saccharum arundinaceum*, *Arundo donax* or *Sesbania grandiflora* and bamboo poles are used, the gaps in between being closed with dry banana leaves.

The planting season varies rather widely in the different tracts of the country. The important factor kept in view is to ensure that the weather is warm and moist.

Terminal stem cuttings or Betts are utilised for planting. The number of Betts planted per acre vary in the different States depending on the system of planting that are adopted and ranges from 3,000 to anything up to 15,000.

After the vines establish, the gardens are given special attention and care to regulate the number of live standards, pruning them for shape and shade, filling the vacancies in the vine rows and trailing the vines on the supports. Manuring, weeding and watering of the plants are done regularly. Dowering the vines to the ground level once a year is a peculiar and special feature in betel vine cultivation. This is done among other reasons, chiefly to rejuvenate them, when, after growing to about ten feet in the course of a year, they show a reduced capacity to

produce fresh normal-sized leaves. Lowering is accomplished by untying the vine from bottom upwards and coiled carefully, leaving one to two feet length of for shoots. It is then buried in a small trench dug at the base of the support, with half the coiled portion in the trench. The top shoot is allowed to climb up on the live support again.

The betel vine is cultivated under a regimen of heavy and frequent irrigation. The manures and the manurial practices differ widely in the different States. The liberal use of bulky, organic manures such as cattle and sheep dung, river or tank silt, fish manure and oilcakes is more or less common. The use of fertilizers is sporadic but is steadily gaining ground.

The picking of leaves commences in about three to six months after planting where the crop is short-lived as in Kerala and Andhra Pradesh. In other areas, harvests are begun when the garden is a year old. With the beginning of the harvests, the plucking of leaves in the garden is done almost every day or week, depending on the demand. The interval of harvesting leaves from the same vine varies from 15 days to two months.

The crop yields vary widely. The gardens in West Bengal are reported to yield, on an average, about 80 lakh leaves per acre per year. The yields in Assam, Andhra Pradesh, Kerala and parts of Mysore range from 20 to 30 lakhs.

The profitable life of betel gardens in Gujarat and Andhra Pradesh is very short, being only two to three years and in Mysore it is about ten years or more. The gardens in Uttar Pradesh last from six to ten years.

The bleaching of betel leaves in improvised chambers is resorted to in the Poona area. The content of reducing sugars and essential oils in the leaf processed in this manner is higher than in the fresh leaf and makes for better chewing due to its richer aroma and taste. It is also valued in Ayurvedic medicinal preparations.

CHAPTER 30

LEMON-GRASS

OIL of lemon-grass is distilled from the leaves of the grass, *Cymbopogon, flexuosus* Stapf. Although the grass is met with in many tropical countries such as Ceylon, Java, West Indies and Malaya Peninsula, its systematic cultivation for distillation purposes is confined mostly to India and Guatemala. India is the largest producer of the oil, and supplies the bulk of the world's requirements; the production in 1958 was estimated at 1,050 tons.

Lemon-grass oil is a basic raw material for the manufacture of many aromatic chemicals which find wide application in the perfumery, soap and cosmetic industries. The modern perfumers use the oil for the preparation of what are known as ionones, large quantities of which were also used in the synthesis of Vitamin A. Besides, the oil is directly used in many pharmaceutical preparations such as pain-balms and disinfectants.

The exports of lemon-grass oil from India during 1959 were 913 tons, valued at about Rs. 89 lakhs. America and the United Kingdom are the principal importers. The other foreign markets for the oil are the U.S.S.R., France, Germany, Switzerland, Netherlands, etc.

Though lemon-grass is met with in the wild state in many of the slopes of the Western Ghats, the important growing areas lie in Kerala, particularly in the northern talukas such as Kuruppampadi, Otakkali, Kothamangalam, Thodupuzha, Muvattupuzha, Vazhakulam, etc., and in the former Malabar district. The total area under it in the State is over 40,000 acres.

CULTIVATION

The grass grows with monsoon rains and is usually cultivated on hill slopes in hard laterite soils. The methods adopted for the cultivation of lemon-grass are very simple and do not involve much expenditure. During February-March, the site

selected for cultivation is cleared of all under-growth of vegetation by burning it. In April-May, when summer showers are received, two or three ploughings are given, and the land is prepared into long narrow beds for sowing the seeds. About 15 to 20 lb. of seeds per acre are sown broadcast, and lightly covered by a brush harrow. Germination is generally complete in about 15 days. One month thereafter a combined operation of weeding, thinning, and filling up the gaps is carried out in the field. No further care or after-cultivation attention is given to the crop except that occasionally during summer the stumps of large trees are burnt and the wood ashes spread in the field to rejuvenate the crop. The crop is also cultivated by transplanting the seedlings raised in separate nurseries. About 12 to 15 lb. of seeds are required for raising sufficient seedlings for planting an acre of land.

The life of the crop varies from five to eight years in each field, depending on the fertility of the soil and seasonal rainfall. The yield of grass is small in the first year of planting, but during the second and third years full yield is obtained, which declines thereafter until the sixth year after which the crop becomes uneconomical unless special attention is paid to it. On an-average, the plantation lasts in the field for about six years. An acre of land, on an average, produces about 15,000 lb. of fresh grass per annum which on distillation yield 25 to 30 bottles (1 bottle---29 oz.) of oil.

CHAPTER 31

PEPPER

THE pepper plant, *Piper nigrum* L., is indigenous to the forests of Kerala and has been . cultivated in India from time immemorial. Large-scale .cultivation of the crop is largely confined to the sub-montane tracts in and below the Western Ghats of Peninsular India. To a smaller extent, it is grown in parts of Mysore, Coorg and Maharashtra. It is also raised in Assam, Sylhet and Khasi Hills, but its cultivation there is- not at present of any commercial significance. Generally speaking, the pepper belt of India consists of the Malabar coast extending from Konkan (North Kanara) in the north to Kerala in the south.

CULTIVATION

The pepper plant is grown on living trees or other supports known as ` standards '. It is a perennial climber which lasts in the plantations for 25 to 30 years, although in some of the well-maintained gardens, the life of the vines has been found to be over 60 years. It grows from almost sea level up to an altitude of 3,500 feet, but the coastal sandy regions are not quite suitable for successful cultivation. The soils found most suitable for the crop are clay loams, but it is also widely grown on red foams and sandy foams overlying the lateritic hill tops of the Western Ghats. As compared to the soils of the East Indies, which consist of fertile volcanic rock debris, the soils of the pepper tracts in India are poor and, consequently; yield poorer crops.

Pepper is an unirrigated crop, raised solely with the help of the monsoon rains. It thrives best in humid and moist climate and in regions where the average annual rainfall is well over 80 inches. Places having an average rainfall of less than 50 inches are not considered suitable for its cultivation. It tolerates a minimum temperature of 50° F. and a maximum of 104° F. Propagation of the crop is done vegetatively by means of cuttings.

As already stated, the pepper vine is a woody climber, and requires some support for growing. The supports or 'standards' used for the purpose in Indonesia, Borneo and other countries of South-East Asia consist of dead-wood posts, but in India, invariably living trees are preferred. Any of the existing jungle trees are used for the purpose, or sometimes seedlings of the local murukku tree (*Erythrina indica*) are specially planted about ten feet apart and the pepper vines set at their base. The vines grow quickly on these 'standards' and cover them with their dark green foliage which forms into the shape of a bush. Though the vine grows to a height of 30 feet and more, depending on the growth of the 'standard', no bush allowed to grow beyond 20 feet in order to facilitate the picking of the pepper spikes when mature.

The vines begin to flower from the middle of July; and depending on the varieties planted, the berries become ripe for harvest from January to March. When ripe, the berries assume a beautiful orange or cherry colour. The fruits, which are carried on slender spikes, begin to appear from the third year after planting. The out-turn of the crop is poor at the first harvest, but goes on increasing up to the sixth year. From the seventh year onwards, full yield can be expected from the plantations.

Preparation of commercial black pepper from the harvested berries is simple. The spikes with the berries are spread on a mat or clean floor and rubbed between the hands or trampled under feet in order to separate the berries. These are then dried in the sun for five or six days. When fully dry, the outer skin becomes black in colour and shrunken in size, and assumes the characteristic wrinkled appearance of the black pepper of commerce.

The area under pepper in India during 1951-52 was about 1,92,300 acres, out of which 1,02,500 acres lay in the Madras State in the two districts of Malabar and South Kanara, while the former State of Travancore-Cochin accounted for 85,768 acres. The other pepper-producing areas, viz., Bombay, Coorg and Mysore, together accounted for the rest.

The production of black pepper in different States of India during 1956-57 was as follows

State	Area	Production
-------	------	------------

		(hundred acres)	(hundred) tons)
Kerala	... ..	2,149	268
Madras	.... .	4	less than 100 tons
Mysore	... ..	183	48
. Total .		2,336	316

It will be clear that pepper production in India is concentrated in the two southern States of Kerala and Mysore which together accounted for more than 98 per cent of the pepper crop in 1956-57.

As compared to nearly 900 tons exported before the war, the present, exports of black pepper from India are almost 17 times-nearly 15,000 tons. From hardly two per cent before the World War II, India's share of the world pepper trade increased to more than 70 per cent during the postwar period. Owing to the unprecedented increase in exports, there has been steep rise in pepper prices in the country, with corresponding increase in the value of the exports. While in 1938-39, the total value of pepper exported from India was only Rs. 3.4 lakh, it increased to Rs. 2065 lakh in 1946-47, and to as much as Rs. 2,317'1 lakh during 1951-52. The fall in exports noticed in 1952-53 was mainly due to speculative buying by the U.S.A.

The main market for Indian pepper is the United States of America. Nearly 30 per cent of India's pre-war exports went to that country. Immediately after the war; the total exports from India increased from 870 tons to 11,002 tons. As much as 38'1 per cent of the increased shipments went to the U.S.A. In 1950-51, the total exports increased still further-to 15,394 tons-and the share of America amounted to 69'7 per cent.

Although India exported pepper regularly to the U.S.A. and Canada during the post-war period, there has been occasional lifting of the Indian product from other hard, currency areas also, such as Mexico, Cuba, Colombia, Bolivia, Guatemala, Haiti, Ecuador, Honduras, Panama and Salvador. The imports into these countries are relatively small and sporadic, but the scope for export promotion appears to be good. Among the other markets for Indian pepper, the U.K., Italy, the U.S.S.R., Egypt and Aden are the most important.

WHITE PEPPER

White pepper is usually believed to be one of the varieties of black pepper. Actually, it is a product of black pepper. It is prepared as follows.

Well developed mature berries of the pepper plant are collected and heaped up. As a result of heaping, the developing warmth generates a process of fermentation of the outer covering of the berries. The berries are then soaked in running water in closed gunnies. Under these processes the pericarp becomes loose and begins to disintegrate. By trampling and rubbing of the mass of such berries, the outer coating is completely removed. Resulting seed is dried, polished and sold in commerce as white pepper. Selection of well developed mature berries and clear running water are two important pre-requisites for obtaining a good product of white pepper.

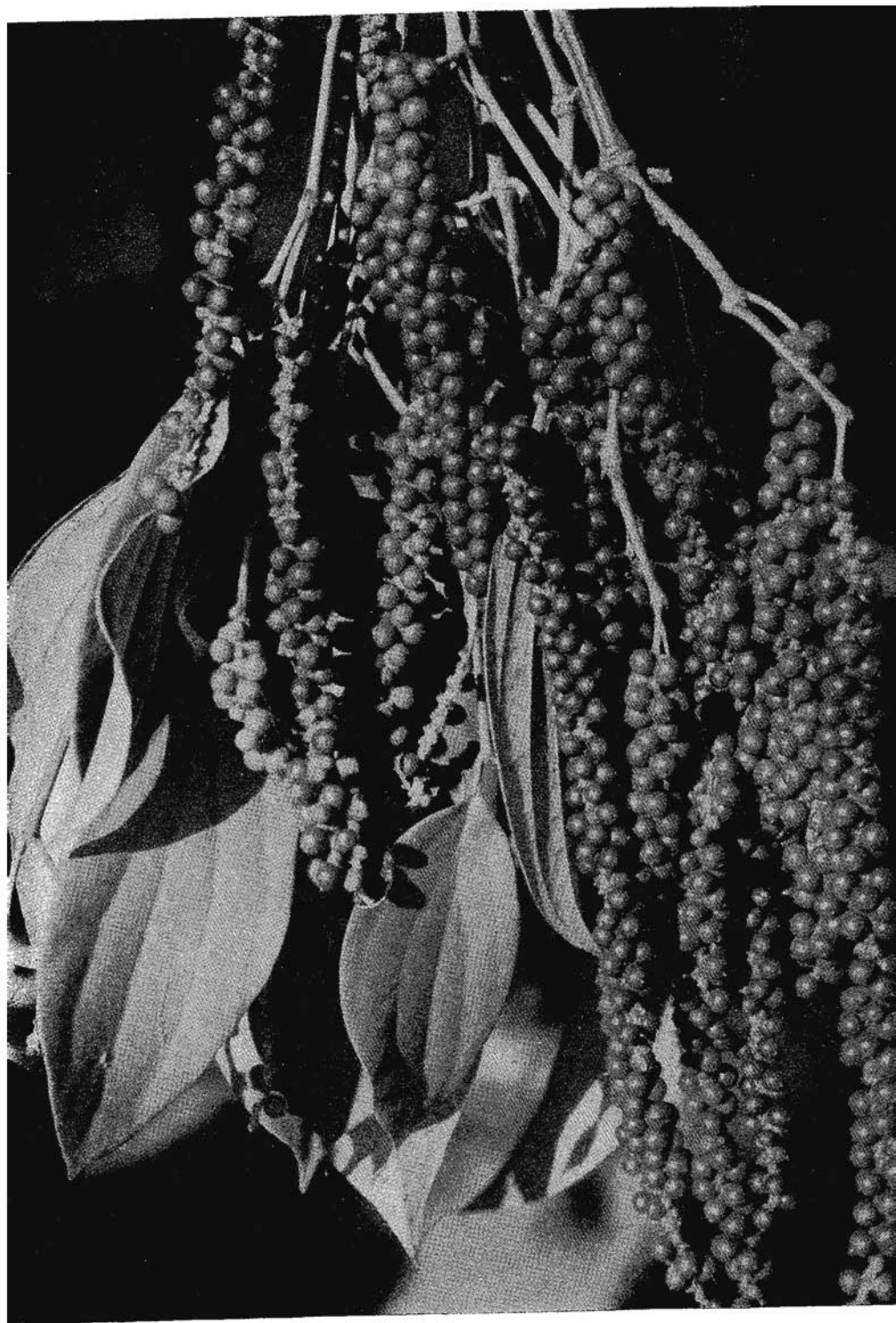


FIG. 26. Pepper plant



FIG. 27. Black pepper vines

CHAPTER 32

CHILLIES

CHILLIES are an important condiment crop in India. They are indigenous to South America, particularly Brazil, and are said to have been introduced into India by the Portuguese. They are grown extensively in most of the South American States, throughout the African continent, in Spain, and in all the Asiatic countries. Their annual production in India is estimated at over 3,40,000 tons. The area under the crop and the yield in 1955-56 in different parts of the country were as follows:

State	Area (thousand acres)	Production (thousand tons)
Andhra Pradesh	400	101
Assam	8	2
Bihar	51	8.
Bombay,	342	59
Kerala	10	3
Madhya Pradesh ..	96	17
Madras	140	74
Mysore	282	40
Orissa	24	4
Punjab	68	13
Rajasthan	44	9
Uttar Pradesh	8	1
West Bengal	16	8
Delhi	1	1
Total .	1,490	340

CULTIVATION

Chillies can be cultivated with ease as an ordinary field crop over a wide range of tropical and sub-tropical conditions.

The plant grows from the sea level up to elevations of 5,000 ft. in tracts receiving an annual rainfall of about 25 to 80 inches. Heavier rainfall during the growing period is not suitable as it leads to rotting of leaves and fruits. It is a crop of a few months' duration, and can be grown both in the rainy season commencing from about June and in the hot weather commencing from about February. In areas of heavy rainfall, planting is done after the monsoon period. In tracts of low rainfall, the crop is grown under irrigation.

The soils best suited for the cultivation of chillies are of the heavy loam type, free from grit, gravel, and stones, and well drained. On the sandy or light alluvial soils a good crop can be raised with heavy irrigation and manuring. Drainage is very important, for the plants sicken in badly drained situations or water-logged areas.

The seed is sown about the end of June or the first week of July in well prepared nursery beds. About 1 1/2 lb. of seed will give enough seedlings to plant an acre of land. When the seedlings are about 40 to 50 days old, they are transplanted. At the nursery stage, frequent irrigation is very necessary. Flowering begins in about one month after transplanting, and progresses apace. In another three weeks or a month, the first crop of green chillies is ready for picking. From about the month of November, the chillies begin to ripen and change in colour, first to a deep orange and then to red. The fruits are gathered as they become red. About the middle of December the picking is in full swing. Irrigation prolongs the life of the plants, and they continue to bear fruit to the end of February. Under dry cultivation, the picking season is comparatively short. After being gathered, the chillies are dried in the sun. If the colour is not fully developed, they are heaped up until the colour develops fully, and are then spread out to dry. They are usually trampled lightly when they are drying, so that they may be flattened and their packing in bags for storage and transport may become easy. Drying usually takes about 15 days. The yield from dry land chillies is about 250 lb. per acre on the average. A good crop may, however, amount to three times this quantity. Irrigated crops yield from 1,500 to 2,500 lb. per acre.

VARIETIES

The chilli plant belongs to the order Solanaceae and the genus Capsicum. The cultivated varieties are classified under the species Annuam. Several varieties or sub-species, differing in shape, size, colour and pungency, are grown in the country. The more important of these are: Acunainatum, Longzcm, Guntur, Grossuna, Cerasiform, Salem, Bird Pepper and Hungarian Paprikas.

CHAPTER 33

CARDAMOM

THE principal cardamom-producing countries are India, Ceylon and Indo-China. The crop is also cultivated to some extent in Central America, particularly in Guatemala.

The average world trade in cardamom has varied from 1,316 tons to 1,117 tons. Both during the pre-war and post-war periods, India has been the largest supplier of this spice in the world market. The average pre-war exports from India amounted to 716 tons, which increased during the post-war period to 917 tons representing 82 per cent of the international trade. The shares of Indo-China and Ceylon in the world trade during these periods are relatively small, and have not exceeded 100 tons each. The exports from Guatemala consist mostly of seeds.

The true cardamoms are obtained from the plant *Elettaria* cardamom-mum which is widely grown in India. These are valued for their higher oil content and aromatic properties, and are considered superior to the bigger sized cardamoms obtained from various species of *Amomum* grown in Sikkim, Nepal, Thailand, Java and a few other tropical countries.

Cardamom has an agreeable aromatic odour and is largely used for flavouring and medicinal purposes. In the Eastern countries, it is chewed with betel leaves, while in northern Europe, particularly in Sweden, Norway, Germany and the U.S.S.R., the cardamom seeds are powdered and widely used for flavouring cakes and pastries and for other culinary purposes. It is also used for flavouring liquors. In medicine, cardamom is employed in the preparation of tinctures and for the extraction of oil. The oil content is far larger in the seeds than in the husk.

In India, cardamom grows wild in many parts of the Western Ghats. It is also cultivated in this region at altitudes varying from 2,500 to 5,000 ft. The plant prefers a warm and humid atmosphere and a temperature ranging between 50° to 95° F., and thrives best in the shade provided by the lofty forest trees. The crop requires a plentiful supply of humus and a fairly distributed annual rainfall of over 60 inches. On account of these

limitations, its cultivation is concentrated in the moist evergreen forest lands of South India.

During 1951-52, the production of cardamom in India was approximately 1,500 tons. The acreage under the crop and yield in different States are given below:

State	Acreage	Production (tons)	Percentage share
Kerala	55, 738	800	55.
Mysore and Coorg ..	39,209	550	38.
Madras ..	15,808	75	5.3
Bombay	, 619	8	0.6

CULTIVATION

The cardamom plant is a tall, herbaceous perennial with branching underground root-stocks, from which arise a number of aerial leafy shoot. As these shoots die, new ones take their place. At the base of the aerial shoots one or more branches of flowers spring up. The flowers which are borne in panicles open in succession from the base to the top and develop into fruits. The fruit is a trilocular capsule, and generally contains 15 to 20 hard brownish black seeds having a thin mucilaginous coating. The fruit varies in shape according to the variety of cardamom. It is generally pale green to yellow in colour when ripe, and the fruit-wall or pericarp is firm and smooth.

Generally, cultural operations commence in February-March. A suitable piece of virgin forest land is chosen and cleared of all undergrowth, leaving the big trees undisturbed to provide shade. Small pits are dug in the cleared areas, ten feet apart and with the onset of the South-West 'Monsoon, two-year old seedlings or rhizomes from the old cardamom crop with their aerial shoots are planted at the rate of two per pit. In August-September, one or two weedings are given, and all stagnant water is drained off. In the second year also sufficient attention is paid to weeding and drainage. These operations are repeated thereafter only occasionally or according to the labour facilities available. The crop begins to yield from the third year onwards, and annually, thereafter. Harvesting commences in

August-September; and lasts up to January or even April. As the capsules do not mature simultaneously, the harvest of the crop is spread over a long period. The fruits are gathered at intervals of 30 to 40 days, and the harvesting is completed in five or six instalments. The first yield is poor, and amounts to hardly 20 lb. of dry capsules per. acre. - By the fourth year, the yield increases up to 30 to 40 lb., and by the fifth year normal crop of 60 to 70 lb., is obtained from the plantation.

After harvesting, the produce is dried in the sun or in specially built drying houses by means of artificial heat. The devices used for artificial drying vary from sheltered mud platforms heated by, a slow fire from beneath to a large drying house or kiln heated by flue pipes. The fruits kept for drying are spread out thinly, and are frequently stirred to ensure even drying.



FIG. 28. Cardamom plants



FIG. 29. Turmeric crop

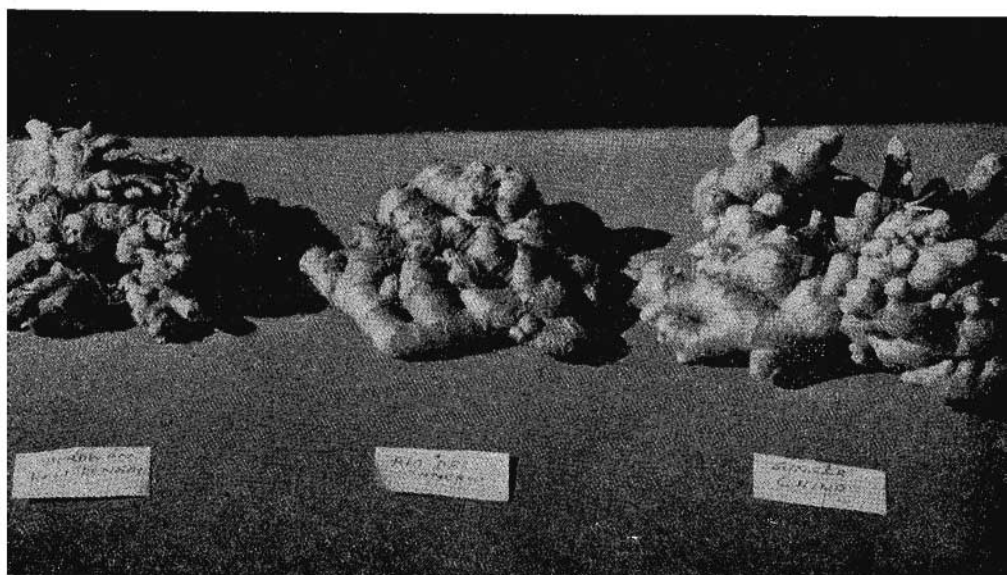


FIG. 30. Improved ginger varieties

The most important cardamom growing region in India is Kerala. In this State, the crop is grown in high ranges, and is largely distributed in the regions known as the Cardamom hills. It is grown largely as a single crop on a plantation basis, the size of the plantation often ranging from 50 to 200 acres. The next important cardamom growing area is Mysore State, particularly of the Munzerabad taluka. of the Hasan district. The cultivation in this State is also similar to that of the Cardamom hills. In Coorg, where the crop grows to a smaller extent, the cultivation is largely confined to the slopes of evergreen forests, and is carried on as shifting cultivation. After a lapse of 10 or 15 years, the cropped. area is allowed to revert to jungle, and new plots are selected for raising. fresh cardamom crop. - Certain portions of Malabar, the Nilgiris, Madura and North Kanara districts also grow cardamom, but the production there is comparatively small, and a portion of the produce is collected as a minor forest produce.

The main market for 'Indian. cardamom is Sweden 'to which nearly one-fourth of the exports go. Sweden imports cardamom both from India and Ceylon. While the Indian cardamom is used largely for flavouring cakes and pastries, the imports from Ceylon are used exclusively 'for the flavouring of liquors. The next important market for Indian cardamom is Saudi Arabia. Both Sweden and Saudi Arabia lift nearly 40 per cent of the Indian exports.

VARIETIES

Depending on the size of the fruits, there are broadly two varieties of cardamoms recognised in India. They are: (i). *Elettaria cardamomum* var. Major Thw., comprising the wild indigenous type; and (ii) *Elettaria. cardamomum* var. Minor Watt, comprising all the cultivated races included under the names of Mysore and Malabar cardamoms. The wild cardamom is 'a primitive variety from which the cultivated forms are derived, but all these varieties and races are inter-fertile and, therefore, produce many hybrids showing considerable variation in the size of the plant, the nature of the leaf surface and flowering panicles, and the size of the fruit capsules:

CHAPTER 34

GINGER

GINGER of commerce is a dry product prepared from the green underground stems or rhizomes of the plant *zingiber officinale*. Although the crop is widely cultivated in tropical countries, bulk of the annual production in these regions is consumed locally as green ginger itself or in the preserved form, only a small proportion of the crop being converted into the dry ginger of commerce. The most important producers of commercial dry ginger are India, Jamaica and Sierra Leone. China also produces large quantities of ginger, but mostly it is in the form of green rhizomes which are used primarily for consumption in the preserved form. There it is not regarded as a spice, nor does it compete directly with the commercial dry ginger of other countries.

The average annual production of dry ginger in Sierra Leone has been found to vary from 1,500 to 2,500 tons, and the Jamaican crop is estimated at 1,000 to 1,500 tons. With her production reckoned at 10,000 tons, India is the largest producer. The present supplies from all these countries vary from 12,500 to 14,000 tons.

While the U.S.A., Canada, the U.K. and Australia import ginger mostly from Sierra Leone and Jamaica, the African territories, Arabia, Aden and other Middle East countries prefer the Indian product.

The annual exports of dry ginger from India to the overseas markets during 1952-53 amounted to 3,217 tons. ' More than half of the exports go to countries of the Middle East, the most important being Aden and dependencies (41.0 per cent), and Saudi Arabia (18.5 per cent). The other important countries are South Africa, Ceylon, Sudan, Egypt, Iran, the U.K. and the U.S.A.

The acreage under the crop and production (dry ginger) in different States in 1956-57 are given on the next page.

CULTIVATION

The most important ginger-growing area in India is Kerala State. The preparation of the dry ginger of commerce is also exclusively confined to this area. To a smaller extent the crop is also grown in parts of Bengal, Assam, Kumaon Valley of Uttar Pradesh, Maharashtra, and Andhra Pradesh.; but in these areas, the crop is produced mainly for its green rhizomes, and is not converted into the dry ginger of commerce. The export trade is, therefore, almost a West Coast monopoly. In Kerala, the main producing centres

State	Area (hundred acres)	Production (hundred tons)
Andhra Pradesh ..	17	4
Bombay	15	5
Himachal Pradesh	28	5
Madras ..	11	4
Madhya Pradesh ..	26	7
Mysore	11	2
Kerala	250	107
Orissa	14	5
Punjab	6	2
West Bengal . . . :	14	6
Total	392	147

lie in the Kottayam division, particularly in the talukas of Muvattupuzha, Thodupuzha, Vaikom, Meenachil, Thalapilly and Kunnathunad. The other main producing areas in the West Coast are in the Malabar district where its cultivation is concentrated in the Ernad taluka. In this taluka, Cherur and neighbouring villages are particularly reputed for ginger cultivation.

Being a rain-fed crop, ginger is grown generally in areas of heavy rainfall. It requires a rich and well drained soil for its successful cultivation. The soils most suited for the crop are sandy or clayey loams or the typical red loams and laterites of

the Malabar Coast. The plant thrives both at sea level and at an altitude of 3,000 ft., as in the Mysore plateau. In the foot-hills of the Himalayas, it is known to grow at an altitude of 5,000 ft. But as in the case of pepper, neither very high altitudes nor the coastal regions seem to be favourable for its successful cultivation. The lower slopes of the Western Ghats suit eminently. Being a tropical plant, it requires a warm and humid climate and certain amount of shade which is believed to be conducive for plant growth-and all these factors are found in that region.

Though ginger is a perennial plant which lasts in the field for more than a year, it is usually cultivated as an annual crop. It takes nine to ten months to mature, and every year a fresh crop is taken. The plant is propagated vegetatively, by means of underground stems called rhizomes.

Before planting, the field is dug up or ploughed, and prepared into long and narrow beds. The beds are heavily manured with cattle-manure and levelled. Seed ginger, consisting of small portions of the underground stems, collected from the previous crop, is then planted in these beds in small pits made at a distance of about 6 to 10 inches each way. Planting is done by the end of May or the beginning of June before the commencement of heavy rains, and the beds are covered with a thick mulch of leaves which serves to protect the young shoots from the fury of the monsoon showers and also serves as an organic matter when it decays. In about two to three weeks, the buds shoot up. In July-August, the beds are weeded and further manuring is given. Generally, 2 to 3 mulchings and an earthing up are done. The plant grows to a height of about two feet, and develops several lateral shoots in each clump. The underground stems develop and become ready for harvest by December-January. As the crop matures, the aerial shoots begin to dry up and lodge on the ground. There is also a yellowing of the leaves. Harvesting is done by digging the whole crop or only portions of it according to requirements.

The quantity of seed ginger used is generally one cwt. or 672 lb., but very often even double this seed rate is used. Under good garden cultivation, the average yield of green ginger is eight to ten times the seed rate. But in certain soils having alluvial deposits, the yield is reported to be as high as 40 times, which goes to show the immense possibilities of

increasing the output of this crop by suitable improvements in agricultural practices.

After digging out, the underground stems are thoroughly washed with water in order to remove the loose soil and dirt sticking to them. These are kept in the sun for a day or so, and then taken to the market for sale as green ginger, or adrak. It is in this form that bulk of the crop is marketed in India. For purposes of foreign export, only dry ginger is used. Its preparation is a local craft confined mostly to Kerala. Small quantities of dry commercial ginger are also prepared at Keliavasna and Borvia in Ahmedabad and Kaira districts, respectively, but the total output is not sufficient to meet even the local demand.

CHAPTER 35

TURMERIC

TURMERIC is grown only in the tropical countries. Its cultivation extends from India to Indo-China, East Indies and part of China.

Turmeric, known as haldi in Hindi and manjal in Tamil and Malayalam, is used as an important condiment almost in every Indian home, and has been cultivated in India from very ancient times. The crop grows from sea level to an altitude of 4,000 ft. In higher altitudes, it is met with in the wild form both along the Eastern and Western Ghats. The soils most suited for its cultivation are sandy and clayey loams. The crop requires proper tillage and careful cultivation. It cannot stand water-logging or alkalinity in the soils. It is grown both under irrigation and as an unirrigated crop. On the West Coast, it is cultivated solely with the help of monsoon rains.

The principal turmeric-growing areas in India are the East Coast, distributed mainly in the two States of Andhra Pradesh and Orissa. To a smaller extent the crop is also grown in parts of Maharashtra and Madras. In Andhra Pradesh, turmeric growing is concentrated in the Guntur district, particularly at Duggirala. By far the largest supplies are obtained from this source. Other areas of large-scale turmeric cultivation in the State are the districts of Cuddapah, Krishna and East and West Godavari. Tiruchirappalli, Salem and Coimbatore districts of Madras State are also important turmeric-growing areas.

Orissa is the next important growing area for turmeric where production is concentrated in the districts of Ganjam, Phulbani and Koraput. Other main centres of turmeric production in the country are Gujarat, and Thana, Khandesh, Sangli and Kolhapur districts of Maharashtra.

Among the other States which are important for this crop, may be mentioned Uttar Pradesh, Madhya Pradesh, Mysore, West Bengal, Rajasthan and the Punjab.

On an average, the crop covered an area of 1,55,030 acres during the year 1955-56, and total production of dry cured turmeric was about 39,166 tons.

There are no imports of turmeric into India from any country. The exports of cured turmeric from India to the foreign markets during 1951-52 mounted to 10,585 tons, representing about eight per cent of the total production. The rest of the crop was consumed within the country itself.

The principal importers of Indian turmeric are Ceylon, South Africa, Iran, Aden and dependencies, the U.S.A. and the U.K.

The area under the crop and production in different States in 1955-56 are given below:

State	Area (acres)	Production (tons)
Andhra Pradesh	42,152 '	63,583 `
Bombay	18,904	26,786
Madhya Pradesh ..	504	189
Madras	7,989	11,001
Orissa	54,263	37,475
Punjab_	25	13
West Bengal	600 ,	331
Mysore	2,751	2,971
Rajasthan	592	294
Uttar Pradesh	280	516
Kerala	11,108	12,171
Total . .	1,39,168	1,55,330

CULTIVATION

The crop is propagated vegetatively by means of its swollen under ground stems known as corms. It requires a fine tilth, and hear application of manure. The preparatory cultivation consists of ploughing the field six times, breaking the clods, and removing stubbles, roots an weeds. Cattle manure is then applied at the rate of about 40 cart-loads per acre, and the field prepared into narrow beds with facilities for irrigation and drainage. During April to July the corms are planted in these bed six to nine inches apart in the furrows and 16 inches apart

between the furrows. After planting, the beds are levelled and a thick mulch of leaves is put on it. Quick-growing vegetables and root crops like colocasia and yam are also sometimes planted in between the beds. The corms set forth aerial shoots above the ground in about a month's time, and make rapid growth: One or two hoeings and weedings are given, and the beds are earthed-up, side by side with the harvesting of the minor vegetables and root crops, at the close of the South-West Monsoon. By November, the leaf growth of the turmeric crop is fairly complete, and the corms below begin to thicken and to develop uniformly deep colour. About February the leaves begin to turn yellow and dry up, which is an indication of the maturity of the underground stems or corms. Harvesting commences in March and continues till the end of April.

Harvesting of turmeric has to be done with great care. The whole lump consisting of both primary and secondary branches known as 'fingers', as well as the main thickened portion known as the 'bulb' has to be lifted up without injuring the corms. The leaves and roots are then cut off, and the bulb and fingers separated from each other. Very small quantities are marketed in this raw form. The bulk of the crop in India is marketed as dry cured turmeric.

The quantity of seed turmeric used for planting varies from 750 to 1,500 lb. per acre, and the average yield of green turmeric is generally eight to ten fold. Much heavier yields are, however, obtained under more intensive methods of cultivation.

Curing of Raw Produce. The green turmeric has to be cured properly before the commercial product can be obtained. Curing consists mainly in boiling and drying the harvested produce and giving it a polish for improving its appearance.

After harvesting, the raw green turmeric is heaped up and covered over with turmeric leaves, and kept in this condition for some time. The raw produce is then transferred to an earthen pot or large iron pan which is filled with water, the water level standing two to three inches above the level of the turmeric. After covering with dry turmeric leaves, the vessel is boiled over fire. When the rhizomes become soft to touch, these are removed from the pan, thinly spread out, and dried in the sun. After five to seven days of drying, the produce becomes fit for storage and sale. After it is quite dry, it is cleaned to remove roots and other

parts, and then rubbed well between hands. It is also polished by means of special appliances. The produce is then sorted out into fingers, bulbs and splits, and also graded into large and small sizes according to requirements.

VARIETIES

There are no sharply distinguished varieties under cultivation, but some types grown in certain localities are reputed for their colour. The Malabar variety is said to have better medicinal properties, particularly for the treatment of cold and catarrh, while the types grown near Poona and Bangalore are specially esteemed for the depth of colour. The wild turmeric is distinguished from the cultivated varieties as *Curcuma aromatica* because of its fragrant stems. *Curcuma amada* is another type of turmeric grown in many parts of the East Coast where it is known as mango-ginger. Its resemblance in taste and smell to green mangoes when tender has probably given rise to this local name. The rhizomes of this variety are much thinner than those of other varieties, and are whitish in colour instead of being yellowish as is the case with other varieties. The most popular variety cultivated for commercial purposes is, however, *Curcuma longa*.

CHAPTER 36

OTHER SPICES

I. CORIANDER

CORIANDER (*C. satiaum* Linn.), a native of the Mediterranean region, is grown extensively in India, Russia, Central Europe, Asia Minor and Morocco.. In India it is cultivated in all the States, the more important being Andhra Pradesh, Assam, Maharashtra, Madras, Uttar Pradesh, Mysore, Himachal Pradesh and Madhya Pradesh, which have 2,55,037 acres (1955) under it distributed as follows:

State	Area (acres)
Andhra Pradesh	1,07,884
Assam	7,800
Bombay	29,097
Madras	59,610
Uttar Pradesh	5,784
Mysore	44,000
Himachal Pradesh	22
Madhya Pradesh	840
Total . .	2,55,037

Coriander is. An important condiment used widely in all parts of India A major portion of the produce is consumed within the country itself. A small quantity is also exported mainly to Ceylon, Straits Settlements Malaya and East Africa.

The fruits are used extensively in the preparation of curry powder pickles, sauces, soups, sausages and seasonings. They are also employee for flavouring pastries, cookies, buns and cakes and tobacco products Coriander is also used for flavouring liquors, particularly gin.

Coriander is cultivated mostly as a rain-fed crop, either pure or mixed with other crops. It is also grown as an irrigated

crop in some areas. The sowing time differs in different parts. In Bengal, Uttar Pradesh and the Punjab, the seeds are 'sown during winter; in Maharashtra and Gujarat during monsoon months; in Madras during autumn; and in Mysore and some parts of Madras from May to August and from October to January. The seed rate also varies from place to place. In the Punjab it is between 16 to 25 lb. per acre; in the South it ranges from 10 to 15 lb. per acre.

Germination of the seeds takes place in 10 to 25 days after sowing. Two to three weedings are considered necessary for the crop, and irrigation is provided whenever required. The manurial requirements of the crop have not been worked out in India. However, experience in other countries shows that manuring increases the yields significantly.

The crop is ready in 3 to 3 2 months after sowing. The plants are then pulled out along with the roots and dried. Thereafter, the fruits are threshed out, further dried in the sun, winnowed, and stored. The yields vary from place to place depending on the nature of cropping and seasonal conditions. In the Punjab, an yield of 700 to 1,000 lb. per acre is common, while in Mysore it is 1,800 to 2,000 lb. per acre when sown pure, and 800 lb. per acre when sown as a mixed crop.

II. CINNAMON

The cinnamon of commerce is the bark of the tree *Connamomum zeylanicum*, Breyn, which belongs to the aromatic natural order of Laurineae. It is said to be indigenous to Ceylon, southern India, Burma and the Malayan Peninsula. It occurs wild in the southern coastal tract of western India up to an altitude of 6,000 ft. It is abundant in regions of 100 to 700 feet above sea level, and thrives up to elevations of 3,500 ft.

Ceylon constitutes the world's principal source of supply of cinnamon. It is also cultivated in India, Jamaica, Cayenne, Seychelles and Brazil, but the exports from these countries are far less than those from Ceylon. The Indian product, which is collected mostly from wild plants, is not rated as high as the Ceylon cinnamon. The bark of the plants grown in Tellicherry is of better quality, but still it is inferior to the Ceylon product.

In India, about 700 acres are devoted to this crop. The cultivation is confined mainly to Malabar and the Nilgiris. The famous 'Brown's Plantation ' near Tellicherry (about 250 acres) is said to be the largest single cinnamon plantation in Asia.

Cinnamon bark is aromatic, astringent, stimulant and carminative. It is extensively used as a spice -or condiment in the form of small pieces or as powder. Powdered cinnamon is also used in confectionery, and manufacture of certain perfumes, incense and dentifrices. The green leaves of the plant yield on distillation a dark oil. In South Kanara, the yield is about 0-75 per cent of the weight of the leaves. It has been reported that the annual production of oil from Mangalore alone is about 3,600 lb. It is sent to Bombay for export. It has been estimated that North Kanara can provide nearly 1,00,000 lb. of leaves for the extraction of oil.

Cinnamon seems to thrive best in alluvial sandy soils in humid tropical climate with an average annual rainfall of not less than about 80 inches.

On the Nilgiri Hill slopes, it can be grown up to an elevation of 2,500 feet. It is reported that the best cinnamon is that grown on sandy, loose soil mixed with humus, at a low elevation. The quality of the bark is greatly influenced by the soil and ecological factors.

Plants are usually raised from seeds. Ripe fruits are gathered and heaped in shade until the pulp turns black and rots. The seeds are then separated, washed and dried.

For commercial production, seeds are sown either in a nursery and the seedlings later transplanted in the field, or in groups of four or five in situ in the field in sheltered situations. The usual time of transplantation is October-November in South India.

Plants are also propagated from cuttings or young three-leaved shoots or by layering.

Weeding of the field is done two to four times a year. In the South, manuring is done with cowdung and cocoanut poonac (oilcake).

The trees are coppiced in the second or third year of their planting to induce the formation of shoots. Five or six shoots are allowed to grow for a period of about two years, or until such time as the bark begins to turn brown with the formation of a

corky layer. At this stage, these would be about six to eight feet high and 0.5 to two inches in diameter, and would be ready for being harvested. The best time for harvesting is the rainy season when the bark peels out readily. To effect peeling, the shoots, after they have been divested of side branches and leafy tops, are first rubbed with a piece of hard wood which loosens the bark. Rings are then made at the nodes with a knife. Length-wise incisions are made to connect the rings, and the bark is thus removed in strips. The pieces are bundled, wrapped in coir matting, and left for 24 hours. With the help of fermentation which sets in, the outer layers of the bark get loosened. Then the epidermis, cork and green cortex of each strip are removed by scraping with the help of a curved knife. On drying, the bark contracts and assumes the appearance of a quill. The smaller quills are inserted into the longer ones to form compound quill (about 36 inches long). These are rolled by hand and dried in shade. Sometimes the quills are bleached with sulphur dioxide.

The dried quills are graded into three or four qualities according to their appearance and aroma. Small pieces and the bark of bigger and coarser shoots are sold separately as quillings, featherings and chips, and are used for the production of cinnamon oil.

The first harvest from a three or four-year old plant yields about 50 to 60 lb. of quills per acre. An adult tree, about ten-year old, gives about 150 to 200 lb.

Commercial cinnamon is of a dull pale brown colour, and is not more than 0.5 cm. thick. The inner surface is somewhat darker than the outer.

III. CLOVE

The clove of commerce is the dried unopened flower bud of the clove tree, *Eugenia caryophyllata*, Thumb. A native of Moluccas, it has spread to a number of countries, viz., Zanzibar, the Spice Islands, the West Indies, the Mascarene Islands, Sumatra, Java, Ceylon, etc. The world's supply comes mainly from Zanzibar, and to a lesser extent from Madagascar.

Cloves are used primarily as a spice. They are also used for chewing, especially with betel-nut or pan. They are also

regarded as a cure for tooth ache. Inferior cloves are used for the manufacture of clove oil. The latest product of clove is artificial vanillin which is obtained from clove oil.

The cultivation of clove in India is limited to South India, where it covers only about 200 acres. The main producing areas are the Nilgiris, the Tenkasi Hills, and Kanyakumari in Madras State, and Kottayam and Quilon districts in Kerala State. One of the reasons for the cultivation not spreading, in spite of extensive internal demand, seems to be the long pre-bearing period in the life of the plant.

Clove appears to be an insular plant requiring sea-air. However, experience in India shows that it can be grown up to an altitude of 3,000 feet from the sea level, in humid situations which receive an annual rainfall of 60 to 100 inches.

The most suitable soils for clove cultivation are dark loams with a sub-stratum of dark yellow earth mixed with gravel. In India, the crop is found to grow well in sandy coastal belts in open sandy loams as well as in the lateritic soils of Kerala. Water accumulation in the root zone is fatal to the plant.

The plant is usually grown from seed, but can also be propagated by layers. Germination of seeds is generally of a low order but can be improved if the seed, or 'mother clove' as it is often called, is fresh and is dehusked before sowing. Dehusking is accomplished by rubbing the 'mother clove', after it has been soaked in water for 24 hours following the harvest. To facilitate rubbing, sand or ash is mixed with the seed. Seedlings are raised either in seed-beds or in plant-baskets made of bamboo. When nine inches high, i.e., about a year old, the seedlings are shifted to the field.

Experiments conducted on the vegetative propagation of the crop at the Burliar Fruit Station in the Nilgiris (Madras State) show that inarching done on clove seedlings is successful. A 100 per cent 'take' was recorded on three-year old seedling stocks. The only drawback noticed was lack of vigour. In Orissa, successful grafting has been reported on *Eugenia javanica*, *E. jambos*, *E. jambolana* and *E. aqua*.

No exact manurial and irrigation requirements of the crop have been worked out in India. In the initial stages of growth it has been found that the plant responds well to applications of concentrates like liquid manure and ammonium sulphate. Small

doses of half a Madras measure of liquid manure and 2 oz. of ammonium sulphate per tree when applied twice a year, once at the onset of the South-West Monsoon and again at the beginning of the North-East Monsoon, give good results. Application of river silt at the rate of four to five baskets to an adult tree has also given increased yields. Mulching with cut grass or fallen leaves is very beneficial to young trees.

The tree starts producing flower buds in the fourth or fifth year. In poor soil, the pre-bearing period extends from six to eight years. In the Nilgiris, blossoming takes place in December-January, and the crop matures by April. In the Tenkasi area, it occurs 30 to 50 days later.

In the coastal tracts, the blooms appear in September and the harvest is ready by December-January.

The average annual production of dry cloves per tree in India is estimated at 5 lb. Allowing 100 trees to an acre, and with 60 per cent of these being in full bearing condition, an acre will yield 375 lb. of dry cloves.

The clove buds are usually gathered with the help of hooked sticks. The maturity of the buds is indicated by the change in the bud colour. They are green at first, then become yellowish with a pink tint, and finally turn into a dull blood colour when they are fit to be gathered. a

After gathering, the buds are spread out on mats in the sun, or are dried on zinc plates over a fire. Normally, drying under direct sun takes about four days, and that with fire about four hours. The time required will, however, vary according to climatic conditions.

No distinct varieties of clove have been recorded anywhere. But, in commerce, the produce is classified under different trade names after the places of production. It appears that it might be possible to isolate some types according to tree shape and leaf aroma.

IV. NUTMEG

The nutmeg of commerce is the de-arilled dried seed of *Myristica fragrans*, Houtt., a cultivated tree. A native of eastern islands of the Moluccas, it is also indigenous to Banda island, Amboyna, Gilolo and Western New Guinea. It was introduced in

India towards the close of the 18th century, but has made very slow progress. Its cultivation, like that of clove, is confined mostly to the South, imparts of the Nilgiris, the Tenkasi Hills, and the coastal areas of Kerala. Some trees are also reported to exist in Mysore and West Bengal.

The total area under the crop does not exceed 300 acres. Being dioecious tree, nutmeg has separate male and female plants of which only the female ones bear economic crops. Difficulty of determining the sex of the plants at the initial stages of growth, has been one of the main impediments in the way of extension of nutmeg cultivation.

Nutmeg finds its chief use as a spice. It is grated and used in the preparation of puddings, custards and pickles. Fresh husks of the ripe fruits are also used for preparing jelly. Nutmeg butter is employed in the soap industry. The oil distilled from the leaves is found to have weedicial properties. It can also be used for flavouring dental preparations and confections. It has also been reported recently that the juice of nutmeg husk is a very efficacious mordant for fixing dyes.

Nutmeg grows best under humid tropical conditions. Its cultivation extends from the sea level to elevations of about 2,500 feet, where the annual rainfall is about 60 to 120 inches, and the mean temperature 50° to 100° F. Laterite soils and yellow loamy clays are most suitable for it. The more friable the clay, the better it is for the plants. Flooded ground is fatal to them, and so are excessively dry conditions.

Nutmeg is propagated through seed. In the experiments conducted at the Burliar Fruit Station in Madras State it was found that well developed and tree-burst fresh seeds, when sown under shade, recorded a germination success of 98 per cent within 17 days of sowing. When sown in the open, 92 per cent of the seeds germinated. Rattling seeds or seeds kept in store over a week before sowing, lose their viability and show very low germination percentage. Seed beds should be provided with artificial shade and should not be too wet. Sowing of seeds in situ is not recommended.

Nutmeg responds well to manuring, but excessive application of manure is harmful. In the Nilgiris, the normal practice is to apply, in the month of September or October, 50 to

100 lb. of well rotted cattle manure or compost to each tree. Mulching the trees with grass or dried leaves is also useful.

The trees start bearing within eight to ten years. It takes six months for the fruits to mature after flowering commences. They are collected at different times, but the main harvest season in the Nilgiris is from June to October. The average yield from an adult female tree in the Nilgiris is about 20 lb. of nutmeg (seed) and one pound of mace. A nutmeg plantation would fetch about Rs. 1,800 per acre.

CHAPTER 37

COCONUT

THE coconut (*Cocos nucifera* Linn.) is perhaps the most useful of the tropical palms. It is an outstanding crop in that it provides a variety of useful products, every part of the tree being utilised for some economic purpose. The nuts give copra, coconut oil, coconut oilcake and coconut fibre, which are used for diverse purposes and are of great commercial importance. The use of the trunks of mature trees as timber in house construction, and of the plaited leaves to thatch houses is very common in the tracts where coconut is extensively grown. The inflorescences or unopened spadices are tapped to extract juice or toddy which is converted into jaggery, sugar, vinegar and sweet or fermented drink. In Kerala, a large industry employing hundreds of labourers has been built up around the manufacture of coir fibre and coir products both on a cottage and large industrial scale. The coconut shell is largely used as fuel, and also for the production of charcoal.

The coconut has also the singular feature of yielding, under suitable conditions, the valued nuts almost at, monthly intervals all through its life of about 80 years. On account of all these valuable features, it has been rightly called Kalpavriksha-the 'Wish-granting Tree'-the tree that provides many of the necessities of life. It is, indeed, a unique tree among the economic plants of the Tropics.

Accurate statistics of the world acreage of coconuts are not available. The area is, however, estimated to be about eight million acres. The most important coconut-producing countries are the Philippines, Indonesia, India, Ceylon, Malaya and British South Sea Islands.

The estimated world acreage and production of nuts are given below to show the relative importance of different producing countries.

Country	Area (million	Production (million	Years to which
---------	------------------	------------------------	-------------------

	acres)	nuts)	esti- mates relate
Philippines	.2.45	4,916	1954
India	1.59	4,151	1954-55
Indonesia	1.50	3,200	1936-37
Ceylon	1.07	2.147	1954
Malaya	0 .60	850	1940
British South Sea Islands ..	0.60	750	1929-30
Other Countries	0.70	900	1929-30

India, ranking second in world acreage and production, accounts for about 3,540 million nuts. The. distribution of the area under coconut cultivation in different States in the country, based on the average for the years 1950-51 to 1954-55, is shown below:

State	Area (acres)	Production of coconut (thousand nuts)
Kerala	10,98,502	27,41,141
Madras	1,29,319	4,18,214
Mysore	2,14,752	5,68,478
Andhra Pradesh	83,708	3,11,241
Bombay	20,331	30,021
West Bengal	16,500	22,205
,Orissa	10,468	29,377
Laccadive Islands	7,269	15,474
Assam	2,000	12,787
Andamans & Nicobars . .	4,293	2,500
Total .	15,87,142	41,51,438

Kerala, Mysore and Madras have, among them, the bulk of the acreage. Of late, considerable interest in the cultivation and production of coconuts in India has come in * evidence, and the area is increasing progressively.

VARIETIES

West Coast: Of the varieties of coconut available in India, the West Coast, which is also known as the ordinary or common tall variety, is the one that is extensively cultivated in all the important coconut tracts in the country, and is of great commercial importance. It is found to grow well in littoral sand as well as in the interior and up to an altitude of about 3,000 feet above sea level. It has been in cultivation in India from very ancient times and may, therefore, be considered as indigenous to the country.

The West Coast variety is a long-lived, hardy, multi-purpose palm, yielding nuts, copra, oil and fibre of good quality. The tree also yields, on tapping, good quantity and quality of coconut juice or toddy which can be fermented or converted into jaggery or sugar. In this variety, growers recognize different sub-varieties or forms based mostly on the colour and shape of nuts or bearing capacity. The nuts are generally of medium size, varying in shape from spheroid to linear, with colour varying from green, yellow and yellow-orange to shades of brown. Some of the forms show variation in the thickness of husk, and the thickness of meat or kernel.

Trees yielding a large number of medium-sized round nuts in almost every leaf axil without any tendency for the bunches to buckle or droop are considered the best for planting on a large scale. Under favourable conditions, the variety commences yielding nuts in about six to eight years after planting. The time of first bearing may, however, be prolonged to 10-15 years or even more if conditions are unfavourable. The yield varies according to the ecotypes selected for cultivation, and the conditions under which they are grown. The average yield of copra per nut is about 5 oz. with oil content of about 72 per cent (by chemical extraction on dry basis).

Dwarf: The Dwarf or short variety which has three distinct forms, i.e., producing green, orange, and yellow nuts, respectively, is liked by some planters for its earliness in bearing, short stature and attractive colour of the nuts. The palms are commonly known as Nicobar or Andaman Dwarf, and also by different local names. They begin to yield nuts in about 3 to 3 1/2

years after planting, and throw out bunches with fairly large number of nuts. They are, however, irregular in bearing.

The bunches with attractive coloured nuts are generally used for decorative purposes. The nuts are small in size, and ovoid or round in shape. They are often harvested in the tender nut stage for the sweet water which provides a cool and refreshing drink. The copra obtained from the nut weighs about 3 oz. It is leathery and is not of much commercial importance. The variety is found to be very susceptible to diseases and pests. For these reasons, it has to be considered as an uneconomic variety.

New Guinea: This is a robust palm with tall and stout trunk. The nuts are large, spheroid or ellipsoid in shape, and with colour varying from green to brown. They contain plenty of sweet water in the tender nut stage. The quality of the copra is not as good as that of the West Coast variety. In the gravelly soil of the West Coast, the palm yields, on an average, about 65 nuts per tree per year. It has a cobra content of about 8 oz. and oil content of 66 per cent.

Cochin China : This is a robust palm giving nuts which are large sized, spheroid in shape, and with colour ranging from green to shades of brown. The water in the tender nut is sweet and plentiful. The variety yields about 86 nuts per tree per year. The copra is of fair quality, weighing about 8 oz. per nut, and has an oil content of 66 per cent.

Java: This is a tall variety with fairly stout trunk. The nuts are medium to large in size, and round or somewhat elongated in -shape. It yields about 95 nuts per tree per year. The copra is of good quality, weighing about 7 oz. per nut, and has an oil content of 66 per cent.

Siam: This is a fairly robust palm. The nuts are green in colour and medium to large in size and ellipsoid in shape. The water in the under nuts is sweet. The variety yields about 50 nuts per tree per year. The copra is of good quality and weighs about 8 oz. per nut. The oil content of copra is 74 per cent.

Laccadive Ordinary: This variety resembles the ordinary West Coast variety. The nuts are medium-sized. The yield per tree per annum is about 124- nuts. The copra content is about 5 oz., and the oil content in :he copra 72 per cent.

Laccadive Small: The palm resembles the ordinary West Coast variety in stature, but the nuts are small in size and spheroid or linear in shape. Large number of nuts are produced in a bunch, and the copra is of good quality. The palm is; however, an alternate bearer, and produces not less than 150 nuts per tree per year. The copra content is only 2 oz., but the oil content of the copra is as high as 75 per cent:

CHAPTER 38

ARECANUT

ARECANUT is an important crop of small farmers in India. The palm grows well in warm temperate and tropical regions. Its distribution is confined to the South East Asian countries like India, Pakistan, Ceylon, Malaya and the Philippines. While in Malaya and Ceylon, the crop exists without any organised cultivation, in India the crop demands considerable attention for its proper cultivation and is concentrated in the South-Western and North-Eastern regions of the country, in the States of Kerala, Mysore, Assam, West Bengal, Madras and Maharashtra. The entire Tarai or sub-montane regions of Bihar and Uttar Pradesh, the river valleys of Orissa and Andaman and Nicobar Islands are also potential zones. It likes cool moist conditions. Even though the cultivation is spread over coastal, sub-montane and plain regions, it is most dense in sub-montane regions, particularly in valleys protected against wind. Flourishing gardens exist up to an altitude of about 2,200 feet above mean sea level. These regions fall in areas with heavy precipitation over 80 inches covered mostly by South-West Monsoon. Some areas fall in 30 to 80 inches rainfall regions. North-East Monsoon is quite valuable for the bearing gardens. Future crop prospects depend on some crucial rains in October-January months. The palm is unable to withstand extremes of temperature and wide diurnal variations. The range of mean temperature at which it can flourish is from about 15° C. to 40° C. Direct exposure to sun produces scorching effect on the exposed parts of the palm.

State	Area in acres	Production (lakh maunds)
Kerala	1,45,031	12 - 51
Mysore	76,300	7 - 18
Assam	26,266	2 - 65
West Bengal . . .	4,988	0-51
Bombay	5,045	0 - 52

Madras	4,373	0-29
Andhra Pradesh	386	0.01
Orissa	227	..
Total . .	2,62,616	23 - 67

The arecanut grows in a variety of soils, i.e., in lateritic soils, red loamy types and (to a limited extent) alluvial soils. But the largest area under it lies in gravelly lateritic soils. The primary need is that the soil should be well drained and also retentive of moisture. A stiff clay, though inherently rich, is generally unsuitable as it gets water-logged. Laterite and lateritic loams are well suited. Good drainage is an essential pre-requisite in establishing gardens in low-lying situations or in heavy soils. Irrigation in months when there are no rains is very essential. However, in West Bengal, Assam and certain parts of Kerala, the crop is purely rain-fed. Where irrigation is resorted to, it is done by lifting water from wells or by flow irrigation if the source of supply is a tank, dam or an irrigation channel. For about six months from December to May intensive irrigation is given.

The area and production figures of arecanut for 1959 are given at the bottom of page 204 and the export statistics during the years 1955-58 are given below:

Year	Quantity (standard maunds)	Amount (in rupees)
1955	3,497	5,79,192
1956	3,936	6,76,322
1957	5,223	8,89,557
1958	5,533	13,28,446

The country is chronically deficit in her requirements which is roughly assessed at one third of the total annual requirements. Till recent past, large quantity was being imported annually mostly from the Federation of Malaya, Singapore and Ceylon. Due to restrictions imposed on import and levy of heavy import duty there is now a downward trend of import.

The quantities imported during the years 1955 to 1958 are given below

Year	Quantity (lakh standard maunds)	Import value (crores of rupees)
1955 ..	10 41	3-80
1956	11-34	5-57
1957	8-66	3-46
1958	5-16	1.03

Varieties: Among many species of arecanut which are known, four species are known to exist in India, viz., (1) *Areca catechu* (Linn.),

(2) *Areca nagensis* (Gr), (3) *Areca triandra* (Roat), and (4) *Areca concinna* (Thy). The cultivated arecanut palm exclusively belongs to the *Areca catechu* (Linn).

The palm has a tall erect unbranched stem, very graceful, often reaching a height of 40 to 70 feet depending upon environmental conditions. The height also depends upon the density of planting, the more congested the plantation, the taller are the palms. Stem is cylindrical, diameter varying from five to six inches with scars of fallen leaves in regular annulated form. Stem of young palms is green changing to greyish white colour with age. It is usually strong and tough swaying gracefully with wind but is liable to break if exposed to direct heavy velocities of winds. Thick fibrous roots arise from a bole, 18 to 20 inches long and situated below the ground. Lateral roots spread about two to three feet all around.

The crown is compact at the top having about eight to twelve pinnate leaves and numerous leaflets which are partly free and partly fused. The inflorescence is a spadix enclosed in a boat-shaped, flattened spathe which in turn is enclosed in the leaf sheath. The inflorescence is stalked with numerous branches containing unisexual flowers. The female flowers open only after the male flowers complete their opening in the same inflorescence. Fertilisation occurs usually by pollen from other palms, i.e., the flowers are essentially cross-fertilised. Insect

pollination or wind pollination is the rule. The nuts mature in about eight to nine months after the ovary gets fertilised.

Fruits are of various sizes and shapes-oblong, round or long. Usually, 150 to 550 fruits are found in each bunch. While young, they are green, but on maturing the colour gradually changes from green to orange yellow or scarlet red. The husk is thick and fibrous enclosing a single seed which is generally known as nut. The endosperm or the nut is light brown with wavy lines.

CULTIVATION

The palm is propagated through its nut which is generally selected from healthy middle aged mother palms (25-30 years) having more than ten open leaves, bearing four or more bunches with heavy fruit set every year. Seeds from second and third bunches are preferred and they are harvested by sliding them by means of a rope. Only well developed fully ripe nuts are to be picked out for sowing which should be done soon after harvest preferably within a week.

The seednut sprouts between 40 to 60 days if properly kept moistened which is generally achieved by encasing the seednuts under moist conditions. An ideal method is to sow seednuts in rows, in small beds which are well dug and the top layer filled with three inches of sand and well shaded. The seednuts are planted with their calyx end vertically upwards. They are just to be covered with soil, mulched and watered daily. Three months after sowing the areca, sprouts are ready to be planted in main nursery beds which are also well prepared and applied with cattle manure at the rate of five tons per acre. The shade crop of banana is to be planted at nine feet apart in rows of 12 feet north-south directions. Well-developed vigorous sprouts are to be selected, planted in such nursery beds at a distance of 1' X 1' with the onset of monsoon. Wider spacing may be given if the seedlings are to be kept in the nursery for more than one and a half years. After planting, the beds are to be mulched with green or dry leaves. They are well drained during rainy season and irrigated during summer. Under certain situations the seedlings get infested with mites and certain leaf-spot fungi and blights and one per cent Bordeaux mixture

spraying with a suitable miticide is advocated to keep these under check.

Seedlings of various stages are planted in the main gardens. But only vigorous seedlings which have produced five or more leaves at the end of one year; seven, eight or more leaves at the end of two or three years and having good girth at the base are selected for transplantation. The seedlings are to be, uprooted from the nursery beds with soil remaining attached to the root system.

For raising the garden, pits of about one and a half to two cubic feet are to be dug (in the north-south direction) at a distance of six to twelve feet according to local conditions. Between these pits bananas are to be planted in advance for shade. Transplanting is done either in June where the drainage is good or in September where it is defective. The pits are partly filled with top soil, planted with the seedling and mulched with green leaves. Green manure crops like *Glyricidia* and *Sesbania* are to be raised to provide shade and green leaves.

The gardens are to be kept well drained during heavy monsoon season and regularly irrigated during other months.

When the seedlings are well established in young gardens, apply 15 lb. of green leaves around each just before the South-West Monsoon. Manure the garden after monsoon with 15 lb. of cattle manure, half a lb. of groundnut-cake, three lb. of wood ash and a quarter lb. of super phosphate in pits once a year till they come to bearing. Three ounces of ammonium sulphate and two ounces of muriate of potash may also be used in place of groundnut-cake and wood ash.

The doses may be doubled in the same manuring regime when the garden comes to bearing stage but it is applied in shallow trenches two feet wide, and two feet away from the bole. Inter-cultivation is done once annually and the garden is kept free from weeds.

Of the many diseases of areca palm, *Phytophthora arecae*, popularly known as Koleroga or Mahali, is very serious. Prophylactic spray with one per cent Bordeaux mixture twice a year, one before monsoon and another about forty days after, is adopted. 'Anabe' (*Gonoderma Luciderm*) is another disease reported in certain regions of Mysore and the infested gardens are to be treated with application of sulphur to soil and uprooting

the diseased stump of palms. Stem-splitting and physiological disorders commonly known as Band or Hidimundige are, also reported. Yellow Leaf disease is prevalent in south Kerala region. Mite is the major pest infecting the leaves. of areca palm and spraying of wettable sulphur (1 oz. in one gallon) is advocated.

Arecanuts are harvested when they are tender or fully ripe, according to the requirements of each locality. In parts of Kerala and Mysore, tender nuts are harvested for the preparation of various varieties of Chali supari. The harvesting season starts from June and extends to December.

In South Kanara, North Kanara and parts of Kerala, ripe nuts are harvested, dried and prepared into Chali supari. The harvesting season for ripe nuts commences in October and extends to March. In West Bengal and in Assam also ripe nuts are harvested.

The test of the right stage for harvesting tender nut is by a bite to know the tenderness of .the kernel inside the green fruit and for mature nuts is the presence of uniform bright yellowish colour on all the nuts in the bunch.

The number of bearing palms per acre, is the largest variable factor governing the acre yield of arecanut, besides the stage at which the nuts are harvested, i.e., whether harvested tender for processing into Chikni or when mature for making Chali. Chikni supari is prepared by harvesting tender nuts. which are husked and the tender kernel is either boiled whole or sliced into various categories and boiled in water, coloured with more concentrated extract of the arecanut and dried: Chali .supari is prepared by harvesting mature nuts, dried in sun for over 40 days till the kernel inside gets loosened and husked. For quickening the drying, the mature nuts are sometimes split vertically and dried.

An irrigated crop invariably gives a higher yield than a rain-fed crop. The average yield of tender processed arecanuts ranges from 1,200 to 2,000 lb. while that of mature, sun-dried arecanuts ranges from 1,400 to 1,500 lb. per acre.

Besides the universal use of arecanuts for chewing, the palm is utilised in a number of ways. Its stem is used for making posts, rafters and beams for temporary constructions: Leaf sheaths are used in the place of plantain leaves, made into

headgear for workmen and buckets for drawing water from wells, and employed for packing vegetables for transport to long distances. The leaves are used for thatching roof. The arecanut husk which is the major waste material is rich in manurial resources and can be employed after it is well decomposed. Its use in the manufacture of boards is another possibility.

The nut contains a large quantity of tannin, which can be extracted and used for tanning leather. A few alkaloids found in the nuts are of medicinal value. . Certain steroids, useful in the synthesis of hormones are also found in arecanuts.

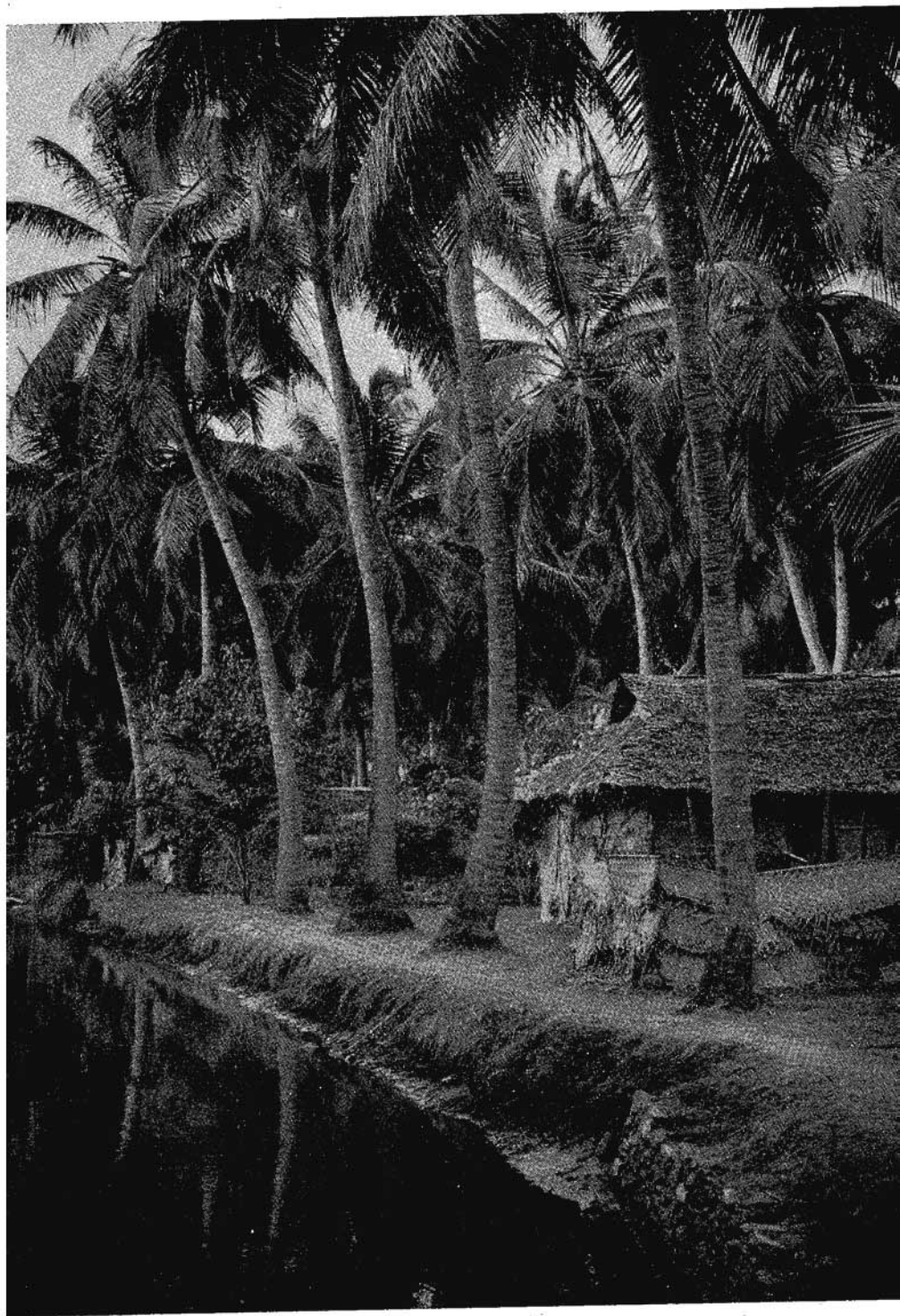


FIG. 31. Coconut plantation

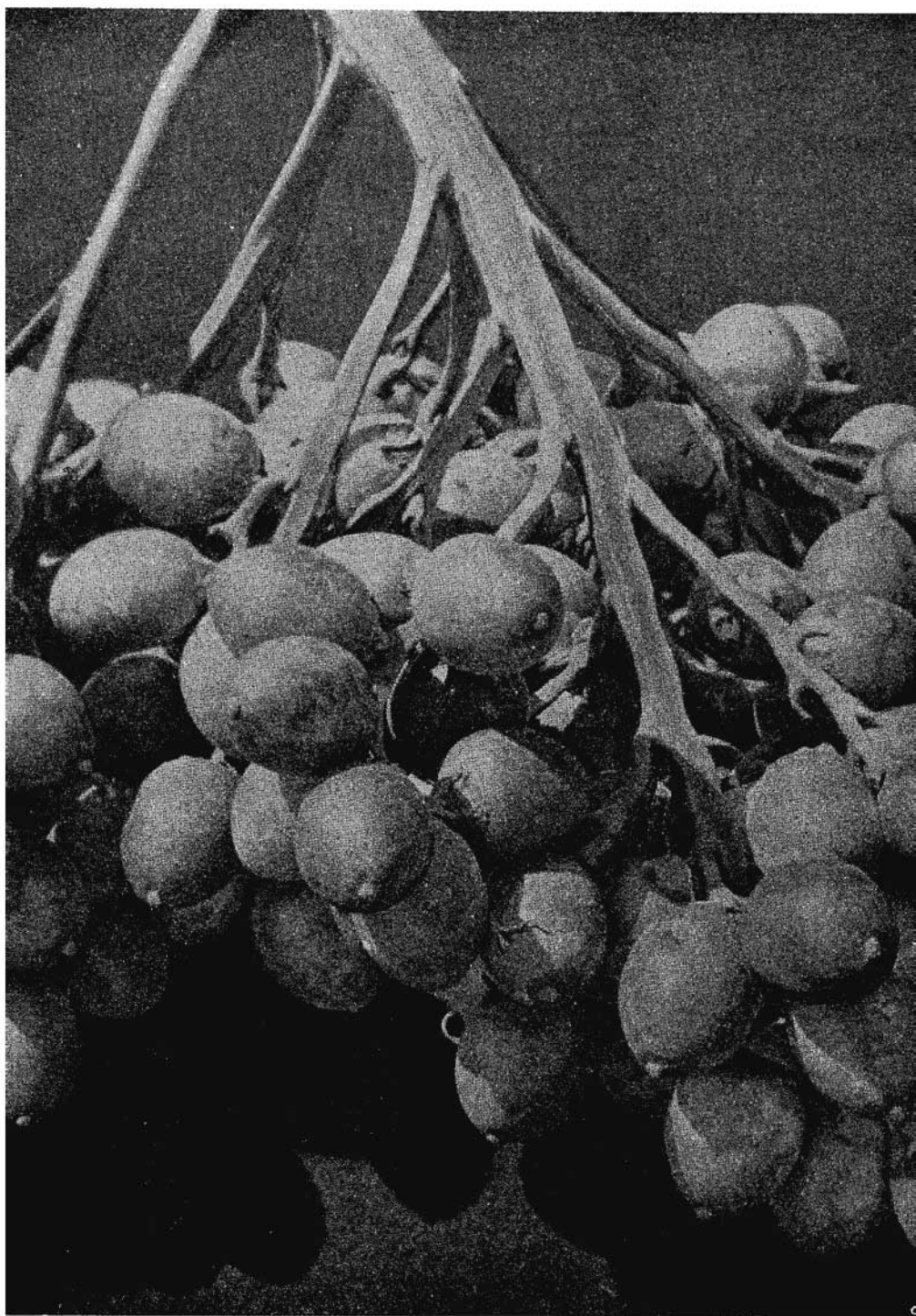


FIG. 32. A bunch of arecanuts

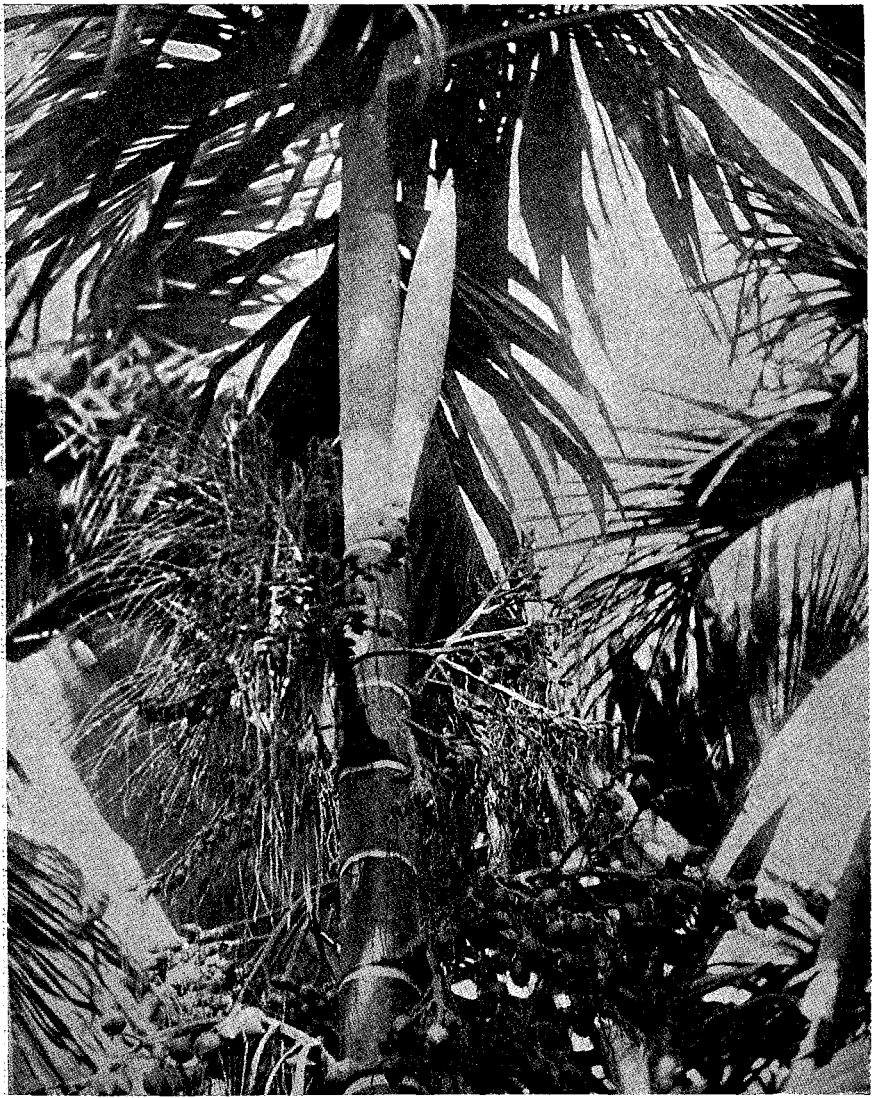


FIG. 33. An arecanut tree

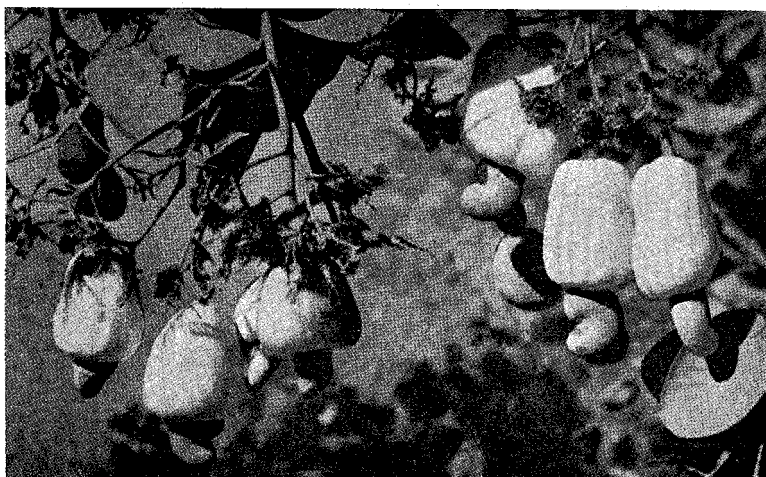


FIG. 34. A cashew tree

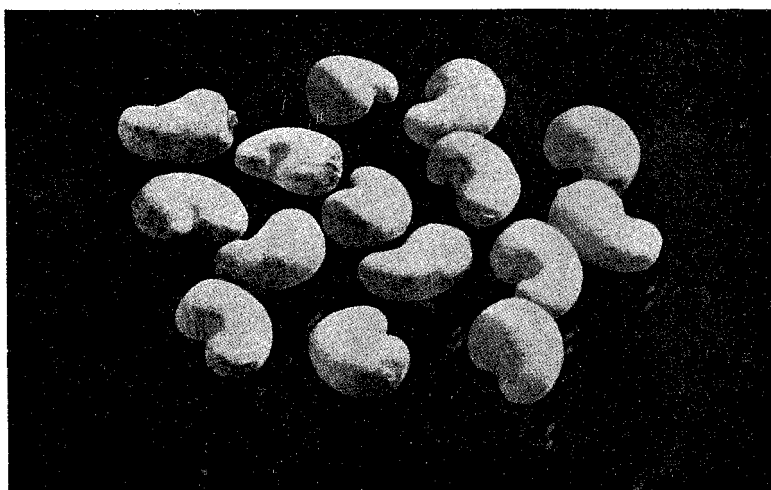


FIG. 35. Cashewnuts

CHAPTER 39

CASHEWNUT

THE cashew tree (*Ancardium occidentale*) is met with in many tropical and sub-tropical parts of the world. The seeds known as cashewnuts, are collected on a commercial scale only in India, East Africa and Brazil. Though it is a native of South America, the Brazilian crop is comparatively smaller, and by far the largest quantities of cashewnut are produced in India and East Africa.. The entire East African crop is, however, exported as raw nuts to India; and the processing and manufacturing of cashew kernels are almost entirely carried out in India. India is thus the principal source of supply of cashew kernels to the world markets. Over 90 per cent of the world demand is estimated to be met by Indian industry, the small balance being contributed by other countries-mostly Brazil. .

CULTIVATION

In India, cultivation of the crop is concentrated in the West Coast and East Coast regions. By far the largest area of this crop is found distributed in the two districts of Malabar and South Kanara. To a small extent it is grown in the districts of Visakhapatnam, South Arcot, Tiru-chirappally, Tanjore and, East Godavari. Cashewnut trees are also found scattered in several other districts of Madras and Andhra Pradesh. In Kerala, which is the next important growing area for cashewnut, the tree is met with extensively, but the talukas of Chirainkal, Kottarakara Kunna-thunad, Trichur, Kilimanoor and Kunnamkulam are the most important. The crop is met with in parts of Ratnagiri district of Maharashtra, and also in some areas of Mysore and Coorg.

Ordinarily, the tree grows to a height of 20 to 25 feet in plantations, but under favourable conditions, attains much greater heights. It has an extensive root system and is, therefore, able to establish itself even on poor and rocky soils. Waste lands are generally selected for the cultivation of the crop. It grows on laterite soils with a rainfall of over 120 inches, as in the West Coast, and does equally well on the sandy soils of the East

Coast districts of Madras where the rainfall is less than 35 inches. It is drought resistant, but cannot withstand frost. Its cultivation depends entirely on seasonal rains, and a regular monsoon is, therefore, essential for getting best results.

At present, no systematic method is adopted for the cultivation of this crop. The tree is grown in gardens and house compounds, inter- spered with mangoes, coconuts and arecanuts. Invariably, it is planted in the corners of numerous house compounds and outlying areas which are considered unsuitable for growing other crops. The cultivation is simple, and does not consist of any elaborate preparatory or after-cultivation operations. When grown on a plantation scale, small pits are dug 25 to 30 feet apart at the beginning of the South-West Monsoon, and one or two dry cashewnut seeds (with shell) put into each pit and covered over. The seed germinates rapidly within two weeks, and develops an extensive root system. Thereafter, practically no attention is paid to the crop in regard to watering, manuring and other kinds of inter-cultivation. Being a very hardy plant it comes up well even under diverse conditions of soil and climate. Flowering takes place in the months of December and January. Light showers at this time are said to be beneficial, whereas prolonged cloudy weather is said to reduce the yield of nuts. The fruits which consist of swollen peduncles, known as cashew apples, and the cashewnut borne on the extreme end, are harvested in the months of March, April and May. The actual yield per tree depends on a variety of conditions, and may vary from about one pound of dry raw nuts per tree in the case of closely planted gardens to as much as 40 to 50 lb. per tree where only 60 to 70 trees are planted per acre. In Kerala, the number of trees planted per acre has ,been found to vary from 50 to 200 in Quilon and Kottarakara, and to over 1,000 in some of the areas in the Trichur district. In the latter case, the crop is grown mainly for fuel purposes. In the forests of Mysore State, where the cashewnut plantations have been recently introduced, the number of trees varies from 75 to 100 per acre which seems to be the optimum number for plantation. On the average, the yield per tree on the West Coast may be taken to be 20 lb. ; in the eastern districts, it is slightly higher, mainly due to the scattered nature of the crop.

The cashew tree generally begins to bear fruit three or four years after planting. Up to the tenth year the yield is poor, but it goes on increasing. Maximum yields are obtained between the seventh and the tenth year. Thereafter, for about 20 years the tree yields a satisfactory crop. The average life of the plantation is estimated at 35 to 40 years.

State	Area (acres)
Madras	.. 1,35,039
Kerala	.. 82,925
Bombay	.. 4,508
Coorg	.. 155
Mysore	.. 500
Total	2,23,127

The total area under cashewnut cultivation in 1951-52 was 2,23,127 acres, distributed as given at the bottom of page 214.

The total supply of raw unshelled cashewnuts in India during 1951-52 has been estimated at 1,02,353 tons, which included 60,000 tons of indigenous production and 42,353 tons of imported nuts. The average recovery of cashew kernels is estimated at 25 per cent in the case of Indian nuts, and 26 per cent in the case of African nuts. On this basis, the total out-turn of kernels of the various cashewnut processing factories in India may be reckoned at 26,000 tons.

The cashew kernels of commerce are obtained by processing the raw unshelled nuts in various ways. These include processing like roasting, shelling and peeling. Roasting makes the shell brittle and facilitates the extraction of kernels, and also imparts a special flavour to the kernel. After roasting, the shells are removed. Unless shelling is done carefully and skilfully, the kernels are likely to get broken and recovery of whole kernels would, consequently, be poor. Shelling is done by hand, mostly by women. The thin brownish skin or outer coating in which the kernels are wrapped up has to be removed next. To facilitate peeling, the kernels are first dried in the sun or in specially constructed hot-air chambers. Like shelling, peeling is

also carried out by human labour, consisting mostly of women and children.

The exports of cashew kernels from India were about 1,000 tons nearly a quarter of a century ago. These increased to 14,000 tons before the war, and came to 27,417 tons during 1952-53. The value of these exports has also correspondingly increased from Rs. 1.29 crores before the war to over Rs. 12 crores at present. More than three-fourths of the export is to the U.S.A. The other important importers are the U.K. and Canada.

CHAPTER 40

COFFEE

THE plant that yields coffee beans is indigenous to the tropical regions of Africa and Asia. But its cultivation has extended to many other tropical and sub-tropical countries lying between 25° N. and 20° S.

A little more than half of the world supply comes from Brazil, and the rest from Abyssinia, Arabia, Britain, Congo, Colombia, Costa Rica, Ecuador, Guatemala, Guiana, Haiti, Hawaii, Kenya, Jamaica, Java, Liberia, Madagascar, Malaya, Mexico, Nicaragua, Panama, Peru, the Philippine Islands, Puerto Rico, Salvador, San Dominigo, South India, Sumatra, Tanganyika, Uganda and Venezuela. Brazil leads in the acreage under the crop, followed by Colombia, Gold Coast, Nigeria, Rumania, Indonesia, Venezuela, Guatemala, Salvador and Haiti. Quantitatively, India is quite down in the list of coffee-producing countries, but the quality of her produce gives her an eminent position. Indian coffee is classed as 'mild coffee', and fetches very good price.

The total area under coffee in India is 2,68,472 acres, or nearly 1 ~6 per cent of the world figure (about 16 million acres). Its cultivation is confined to the States of Mysore, Madras, Coorg, Kerala, and parts of Andhra Pradesh, Assam, Madhya Pradesh and Orissa. Mysore State accounts for the largest share of the total production. The acreage and production as recorded in 1957-58 are given below:

State	Area (thousand acres)	Yield (thousand pounds)
Mysore (including Coorg) . .	154	70,625
Madras . . .	64	17,185
Kerala . . .	50	9,935
Other States ..	..	143
Total .	268	97,888

Coffee holdings in India vary from one acre patches to 1,000-acre plantations, but most units are not bigger than ten acres. The area under the crop has shown marked fluctuations since the beginning of this century. In 1896, the plantations covered about 3,04,000 acres, but in 1920 the leaf



FIG. 36. Tapping rubber



FIG. 37. Coffee plant

disease and the prices then prevailing reduced the acreage to a little over 2,00,000 acres. The peak figure of 1896 has not been reached since, but good management, improved cultural practices, and anti-pest measures have increased the yield per acre.

CULTIVATION

The coffee plant is delicate and fastidious in its requirements: It thrives well in a warm and humid climate. A spell of dry weather from mid November-December to January-February facilitates ripening, harvesting, processing, drying and despatch of the crop to curing facilities as well as helps the plants to stand winter in which the cropping wood and flower buds mature. It cannot stand frost. Nor is extreme heat good, for it. Its cultivation is, therefore, restricted to areas where the mean annual temperature does not exceed 70° F. Generally speaking, the temperature range required for its successful cultivation is 55° F. to 80° F. Ordinarily, it needs 60 to 80 inches of well distributed annual rainfall; but with proper cultivation it can grow even in areas having as high a precipitation as, 130 inches. A prolonged drought causes serious damage, and reduces the yield. Cultivation is possible up to an elevation of 6,000 feet. The soils most suitable for the plantations are rich, well-drained friable soils containing a good quantity of vegetable mould. The optimum pH value for a coffee soil ranges from 6.0 to 6.5. The soils of the Western and Eastern Ghats, the main coffee-growing tract in India, contain a fairly high percentage of iron, aluminium oxide and nitrogen, but are poor in lime and phosphoric acid.

The situation and aspect of a plantation have considerable influence on its fortunes. In South India, plantations are generally established on the gently sloping lands or the sides of valleys, and on the spurs of the ghats. Protection from strong winds, especially during the rains, is essential. A northern aspect is better in South India as it makes for uniformity of temperature. For similar reasons, another good aspect would be an eastern one. Completely or partially cleared patches in jungles are the best places for setting up coffee plantations, provided other requirements are met.

As a rule, coffee is grown from seed, though vegetative propagation has been tried with considerable success. Indian planters follow the first method. The seeds for sowing are gathered from selected bushes of assured productivity and quality from known varieties. The best fruit are picked when fully ripe on the branches. The fruit pulp is removed without injuring the parchment skin, and the beans are dried in shade. Sound beans, uniform in size, are then selected for sowing.

Seedlings are raised in specially prepared seed-beds, and transplanted into nurseries before being planted in the field. These seed-beds are established in the best part of the plantation, generally on a gentle slope near a water source. Sometimes the seedlings are raised in special baskets of split bamboo. The advantage of using baskets consists in the ease with which the seedlings can be taken over long distances for planting in the field without disturbing the soil.

The seeds are sown usually from January to March, transplanted in nurseries in about 8-12 weeks, and finally planted when about 15-18 months old, i.e., in June-August of the following year. Plants grown in baskets, which are about eight months old, are planted by the middle or end of August to the beginning or end of September, when the severity of the South-West Monsoon rains has worn off, while bed plants from the nursery beds which are 15 to 18 months old are planted with the onset of monsoon, from middle of June to the end of July depending upon weather.

The crop is grown mostly under shade in India, though in other countries this practice is not common. Shade protects the plants against extremes of temperature and rainfall, and may also tend to remove leaf disease and stem borer attacks. It also protects the plants against hailstone damage, and checks soil erosion. It also helps in maintaining a good organic matter contained in the soil by converting the leaves dropped from plants into humus.

There are two kinds of shade trees, viz., permanent and temporary. For the former, usually, trees belong to *Ficus* sp., *Albizia* sp., *Artocarpus* sp., *Grevillea robusta* (silver oak) and other trees are planted while the temporary shade almost always consists of *Erythrina* *Lithosperma*, popularly known as Dadaps. Leguminous trees when used help in adding nitrogen to the soil.

Besides the shade plants, temporary green manure or cover crops like *Crotalaria* spp., *Tephrosia* spp. and *Indigofera* spp., may be grown in young plantations to cover the ground between rows, and to keep down weed growth and . shade the young coffee plants. These also provide green manure.

Post-planting cultural operations consist mainly of manuring, plant training, shade regulation and plant protection operation of weeding, sometimes hoeing or digging, and re-planting substitutes wherever original seedlings die out. Weeding is particularly necessary in young clearings. Plant protection operations are considered essential.

On virgin soils in the first few years, coffee may yield fairly well without much manuring. But it becomes necessary to replenish the soil nutrients through manuring to obtain sustained good yields every year. Formerly, cattle manure, oilcakes and bonemeal were in general use. These have now been replaced by standard fertilizer mixtures.

Grafting is adopted particularly for working up clones of different selections and for improving the yield of existing plantations by top grafting with scions from high yielding trees and also as an economic means for rehabilitating invested areas by using resistant root-stock. The best time for grafting in South India is May July when more than 80 per cent success has been recorded.

The plants start bearing fruit when three years old, and continue to yield for 30 to 50 years or even more.

In South India, flowering. commences after the first summer showers, usually about the end of March or beginning of April. The berries take about eight to nine months to ripen, and are ready for picking by October-November. The picking season varies in different areas according to` their altitude and climate. In Mysore State where the crop is derived from one flush of blossoms, picking is completed in three or four rounds by February-March. In the higher elevations of the Nilgiris where the crop is had from several blossomings, picking has to be carried out in a number of rounds lasting till about May. This later tendency is now being controlled for proper cultural operations.

Picking is a selective operation, and is confined to ripe berries: Unripe berries give rise to poor quality coffee, while the over-ripe ones are difficult to pulp. In the first round of picking,

each bush has to be carefully examined for collecting the prematurely ripe and dried up fruits. This is known as fly-picking. Later on, when the majority of fruits ripen, they are systematically picked, the whole estate being covered row after row. The fallen fruits are gathered as gleanings.

Yield depends on a number of factors, such as the variety cultivated, conditions of climate and soil, plant spacing and training, density of shade, cultural operations and age of the plants. Thus, it varies from 4 to 1012 cuts per acre.

Processing and Marketing. The treatment of the picked fruit is long and elaborate before it is marketed.' There are two methods of processing it, i.e., the dry method and the wet method, both seeking to rid the bean of various coverings-the skin, parchment, pulp and outer skin. Small plantations, unable to afford the equipment needed for the wet process, employ a set of operations collectively called the dry method. The berries are sun-dried for two to three weeks, and the coverings removed by hulling. The beans thus obtained go by the trade name of 'Cherry'. The wet method consists of a series of operations like pulping, fermenting, washing and drying, for which elaborate arrangements have to be made. The product prepared through the wet process is called 'Plantation' or 'Parchment'.

Before the World War II, about 60-75 per cent of the coffee produced in India was exported. After the sudden fall in exports at the outbreak of war, attempts were made to increase internal consumption. A chain of coffee houses was established by the Indian Coffee Board, and coffee drinking has become quite popular now. Over one-third of the crop produced is now, earmarked for export. This is more than pre-war exports.

VARIETIES

Of about 60 known species, which grow as shrubs or small trees, only four or five have commercial importance. Among these, *Coffea arabica* is the most popular and is by far the most widely cultivated species. *C. liberica*, *C. robusta*, *C. excelsa* and *G. stenophylla* are other important species, and are cultivated chiefly because of their ability to thrive under a wide range of climatic and soil conditions, and their greater resistance to pests and diseases. Besides the cultivated species, as many

as seven wild species have been recorded from the tropical Himalayas and higher elevation districts of South India. None of these has proved economically important so far. However, *C. bengalensis* is often cultivated in gardens for its fragrant flowers, and its seeds are reported to be used for preparing coffee.

C. arabica. It is considered to be a native of Abyssinia and adjacent part of Sudan and was introduced into India through Arabia. It is cultivated in many countries, and accounts for nearly 90 per cent of the world supply of coffee. It produces the finest quality of coffee, but is susceptible to leaf disease (rust) and other diseases.

1. Chiks. It yields large round beans, and is a favourite in foreign, markets. However, due to its susceptibility to leaf disease, the area under its cultivation has shrunk greatly.

2. Coorgs. It is a selection from the Chiks variety. The beans are greenish or bluish in colour, and are longer and bolder than those of Chiks. Though it was resistant to leaf diseases first, later it became highly susceptible to the diseases.

3. Kents. It is the most popular type in India at present and is grown all over Mysore and Madras Hills.' It is more resistant to leaf disease than the Coorgs, and produces bolder beans, somewhat greyish in colour. It is a vigorous grower and gives good yields under good husbandry.

4. Other Varieties. Maragogipe, Bourbon, Amarello, Blue Mountain, etc. are other types grown on a small scale. Besides these, a large number of hybrids and crosses, evolved by inter-specific and inter-varietal hybridization, are being tried and tested with a view to securing plants suited to local conditions. As a result of these, four selections viz., S. 228, S. 795, S. 333 and S. 645 have been evolved and are under large-scale distribution. The first two at present account for nearly 30-35 per cent of the acreage under arabica in India. They show resistance to leaf diseases, have vigorous growth and produce good yield.

C. robusta. The plant is much larger and more vigorous than *C. arabica* and is popular particularly in the lower elevation districts of South India where *C. arabica* does not appear to thrive well. It is also more hardy and tolerant to leaf disease and white stem borer.

The species is a native of Congo and Uganda. This forms about 33 per cent of the total planted area under coffee in India.

The area under *C. robusta* has gradually increased. Many abandoned arabica plantations have been replanted with it. In Kerala, it forms the major crop, and is grown in gardens as an inter-crop along with coconut, banana, mango, and chiefly along with oranges and pepper. The quality of *C. robusta* is much inferior to that of *C. arabica*. Further, *C. robusta* is an erratic cropper.

C. liberica. It is a native of tropical West Africa, and has been tried in parts of Mysore and Kerala. It has not become popular as it is of poor quality and the beans which are large, have not found favour in the market. .

It is used mostly in blends. It has also been employed widely for hybridization purposes, and as a root-stock for grafting *C. arabica*. Some of the hybrids are vigorous and are considerably resistant to leaf disease. Like other hybrids, however, they suffer from a high degree of sterility.

C. stenophylla. A native of West Africa, it has been grown for experimental purposes in India. This species has not so far proved commercially important in this country or in other countries except in Sierra Leone, French Guinea and Ivory Coast.

CHAPTER 41

TEA

TEA was first cultivated in China, though opinion is divided on the question of its original habitat. The species . is indigenous to South-East Asia, from Assam to China and Indo-China. It is now cultivated over a wide range of tropical and sub-tropical regions extending from 42° N in Soviet Trans-Caucasia to 33° S in northern Argentina. However, the more important areas are confined to the south-eastern region of Asia, comprising parts of China,. Japan, Taiwan, Java, Sumatra, Ceylon and India.

CULTIVATION

In India, tea is cultivated on plains and in hilly tracts up to an altitude of 7,000 feet. The principal areas in the North lie in the Brahmaputra and Surma Valleys of Assam, and in Darjeeling and Jalpaiguri districts of north Bengal. The other tea-growing areas are Ranchi, Dehra Dun, Kangra and Kumaon districts. In the South, cultivation is confined mostly to the hilly regions of the Western Coast, comprising Kerala State, and the districts of south Malabar, Coimbatore and Nilgiris. Then acreage under the crop and the production in 1957-58 are given below:

State	Area (thousand acres)	Production . (thousand lb.)
Assam ..	.. 393	3,5.5,738
Bihar ..	.. 2	217
Kerala ..	.. 97	78,402
Madras ..	.. 76	72,346
Mysore ..	.. 4	3,420
Punjab ..	.. 10	2,434
Uttar Pradesh ..	.. 6	1,626
West Bengal . . .	. 202	1,66,222
Himachal Pradesh	.. 1	115
Tripura	.. 12	4,617

The conditions most favourable for the cultivation of tea are: (i)' narrow diurnal variation in temperature; (ii) generous rainfall distributed through-out the year; and (iii) absence of strong, dry winds and freezing temperatures: The low elevation tracts of upper Assam and north-east Bengal and 'the silly regions of the Nilgiris and Annamalais are particularly noted for tea cultivation. The high altitude districts, such as Darjeeling, produce excellent tea though the crop yields are low. Areas like Ranchi and Dehra Dun districts, where the intensity and distribution of rains are not quite favourable for its cultivation, do not have a good crop.

The plant thrives well in a humid climate, and cannot stand long spells of dry weather at any time of the year. It must receive at least 60 inches of rain yearly and the rainfall- must be well distributed. The upper limit is not known. In the Assam-tea areas, the annual rainfall averages between 50 to 150 inches . and is well distributed, while in Dooars and Darjeeling districts it ranges from 100 to 200 inches though distribution is less satisfactory. The tea areas in the South receive still heavier precipitation.

Tea is a shade loving plant, and develops more vigorously under light shade than in exposed situations. The best range of maximum monthly temperature is 70° to 90°F. When the maximum temperature in shade falls below 75°F. or the average minimum temperature below 65° F.; the growth is retarded. However, a slightly higher temperature than the optimum can also be tolerated by the plant if it is accompanied by very moist conditions. In Assam, the temperature in shade sometimes rises to 98° F., but. this happens always during the monsoon season.

It is essential that tea land on the plains should be well drained, while in the hills, anti-erosion measures be taken. Some of the finest plantations in Assam are found on level ground, 50 to 400 feet above sea level. The soil must be deep and of a moderately open texture throughout its depth. It should be acidic (pH: 4.0 to 5.8), and free from calcium carbonate or reactive calcium. In north-east India, the soils range from the lightest

sands to the stiffest clays and peats. Similar wide variations are met with in the tea soils of South India. Generally speaking, virgin forest soils are the best since their physical condition is good and they are rich in plant food. The productivity of the older estates can be increased significantly by the application of fertilizers and manures. Nitrogenous fertilizers are particularly beneficial, and should generally be used on all lands, new as well as old.

The crop, is usually raised from seed, though vegetative propagation has also been tried with success. -A number -of gardens in north-east India are being -planted-with clonal plants.

The seeds are obtained from cross-fertilized seed bushes. In the north-eastern parts, the seed is collected mainly in November, and in the -southern areas from May to June. The seed loses its viability on keeping, and has, therefore, to be used soon after collection. Seeds to be sent to distant plantations are air-dried- and carefully packed in boxes containing moist charcoal or sandy soil. A wrong choice of seed is highly uneconomical in the long run, since the cost of planting is very high. Once the choice has been made about the quality of tea to be produced, it is desirable to stick to the variety selected.

Seeds are first planted in carefully prepared nursery beds. Seedlings raised in the nursery from one maund of seed suffice for planting three to five acres.

The most suitable, lands for planting tea are forest lands or grasslands, though the former are better suited. Proper drainage is necessary to facilitate retention of water by the soil at the optimum level. The size and number of drains vary with the slope of the land, the nature of the soil, and the amount of rainfall. They are somewhat close in clayey loams and far apart in sandy soils.

Planting systems vary with the nature of land. On gentle slopes and flat lands, tea is planted in lines in square or triangular form. On steep slopes and hill sides, planting is done in lines along the contours. It is usual to mix a small quantity of well-rotted cattle manure or compost with soil used for filling the holes in which the seedlings are set. Organic manure helps to maintain the tilth of the soil as also its moisture-holding capacity.

The plants flourish best under tree shade; and the trees most commonly used for this purpose are of leguminous type.

Special care is taken to prevent weed growth. The bushes are induced to develop laterally so as to shade the ground completely and thus prevent weed growth. Maximum yields are obtained from clean soils shaded by the tea bushes themselves.

The nitrogen requirement of tea is unusually heavy. A crop of 1,000 lb. per acre removes annually from the soil approximately 55 lb. nitrogen. This drain is beyond the average recuperative power of the soil. Regular manuring is, therefore, necessary to sustain yields. Experience has shown that application of nitrogenous fertilizers like ammonium sulphate ensure best results. However, excessive doses under heavy shade reduce yield. Use of bulky organic manures has no advantage over chemical fertilizers. Leaf fall and prunings from bushes provide all the organic matter required for maintaining the soil fertility. Green manuring is beneficial, but is possible only prior to planting, or in young tea.

The plant, when quite young, is pruned to a few inches from the ground to encourage the growth of lateral shoots so that it develops into a bush of the size and shape considered suitable for plucking by hand. After the first low cutting, it is pruned periodically. Heavy pruning is resorted to when the bush becomes too high for plucking or when a part of the plant is affected by disease.

PLUCKING

Tea harvesting consists in collecting from the newly-grown vegetative shoots, the terminal buds and two or three leaves immediately below them along with the intervening stalks. The pluck is considered to be 'full' when it consists of two leaves and a bud; anything less is considered to be 'fine', while inclusion of more than two leaves is regarded 'coarse'. The tannin (polyphenols) and caffeine contents of the leaves decrease with the age of the leaf and when these are low the quality of tea is considered poor.

Several systems of plucking have been developed, but light plucking is considered preferable to hard plucking as it yields leaf of better quality. Besides, bushes lightly plucked are more healthy, and are generally more free from red rust than hard plucked bushes. A satisfactory method of plucking is to '

pluck to the janam' i.e., to pluck by leaving the small unserrated leaf produced by the unfolding of the dormant axillary bud. Heavily pruned bushes are not plucked until the new growth has reached the height of 30 inches from the ground. In the north-eastern parts, tea bushes give five to six flushes in a season, the average interval between pluckings being a week. In South India, plucking goes on all the year round.

Plucking is done mostly by hand by women who go round the bushes and collect the new flushes in baskets. Attempts have been made recently to mechanize the process, and a mechanical harvester has been devised.

A mature bush yields annually about 2 lb. of green shoots. Roughly, the yield of finished tea is about 1,200 lb. per acre. Under suitable climatic and soil conditions and with proper management, the yield may be as high as 44 lb. per bush or 2,500 lb. of finished tea per acre.

In higher elevations, the yield is smaller, but the tea has its own peculiar flavour and characteristics on account of which it enjoys a premium over that grown under humid tropical conditions.

The yield of tea bushes falls off after about 40 years, though bushes as old as 150 years, and giving sustained yields are known to exist.

PROCESSING AND MARKETING

There are several varieties of commercial tea, i.e., Black tea, Green tea, Oolong tea, Brick tea and Let-pet tea. However, the bulk of the crop gathered from Indian plantations is processed into Black tea, and a small percentage into Green tea. The other types have been produced only on- an experimental scale.

A number of operations, such as withering, rolling, fermenting and drying are involved in the preparation of Black tea. These require a high degree of skill and extensive equipment, and production is, therefore, confined to factories. After processing, the tea leaves are sorted, blended and divided into commercial grades such as ` Leaf' grade (Orange Pekoe, Pekoe, Pekoe Souchong), and ` Broken' grade (Broken Orange Pekoe, Broken Pekoe, Broken Pekoe Souchong, Fannings). The

waste left over from sorting and grading is sold as fluff for the extraction of caffeine. . In the case of Green tea, the withering and fermentation processes are omitted, and the leaves are heat-treated, rolled, dried and polished. The common grades of Green tea are: Young Hyson, Twankey, Fannings or Soumee and Dust.

India is the largest producer and exporter of tea in the world excluding perhaps China in respect of which statistics are not available. Out of a world output of 1,487 million lb. in 1957-58, India produced 685 million lb., Ceylon, 398 million lb., Pakistan, 46 million lb. and Java and Sumatra, 28 million lb. Its consumption within the country is considerably lower than the production. Prior to 1915, the quantity consumed amounted to 30 million lb. However, as a result of the sustained activities of the Indian Tea Market Expansion Board, the internal demand has expanded steadily and in 1948, about 1.50 million lb., or nearly 25 per cent of the total annual production was consumed.

The low internal consumption permits India to export large quantities of tea. Among the importing countries, the U.K. comes first, taking nearly 60-70 per cent of the total. The other importers of Indian tea are the U.S.A., Canada, Australia, Russia, Iran, Afghanistan, Egypt, Ceylon and Tibet.

VARIETIES

Tea belongs to the genus *Camellia* which has about 81 species of evergreen shrubs and trees. It, along with its close relative *C. taliensis* (W.W. Sm.), is included in a distinct group within the genus. The group stands apart from all other groups of the *Camellia* species, both morphologically and chemically. .

C. sinensis is an evergreen shrub growing to a height of 1'5 to 15 metres when left to itself. Under cultivation, it is usually pruned down to a height of about 80 cm. and maintained as a bush. Numerous varieties and races of the plant, variously classified by different authorities, are known.

Botanists usually recognise two varieties of tea, namely the China variety (*C. sinensis* var. *sinesis* L.) and an Assam variety (*C. sinensis* var. *assamica* Masters). The China variety is typically a shrub, 1'5 to 3'0 metres tall, with relatively small, hard, dark green leaves 4 to 7 cm. long. The Assam variety is typically

a small tree, 10 to 15 metres tall, with much larger, more supple, light-green leaves, 15 to 30 cm. long.

The China variety is more hardy than the Assam variety, but its crop yield is lower. Tea made from the two varieties differs fundamentally and one tea is no substitute for the other. Forms of the Assam variety

with either dark or light green leaves are cultivated, the darker forms being considered more hardy by many tea planters. Similar tea is made from either forms.

A Linnean nomenclatural system does not adequately describe the cultivated crop because large parts of it are composed of inter-grades and crosses between the two varieties, and hybrids between these varieties and other lesser known forms, some of which may be recognisable at species level.

Commercial tea seed is obtained from perennial orchards maintained exclusively for that purpose. They are established by mass selection of seedlings of varied and more or less cross-bred ancestry. Some orchards give rise to very mixed progeny populations, others to comparatively uniform population. Each source has a distinctive trade name under which the seed is sold (e.g., Domjan) and this name is commonly said to designate the *jat* (literally caste) of the source and its progeny. The number of morphologically disparate progenies is very much less than the number of distinctively named progenies. Some are characterized by rather long narrow leaves; others by notably large leaves and so on. They have been grouped by some writers under special names; for instance, plants with long narrow leaves have been called 'Naga tea', and those with a broader, larger leaf have been called 'Lushai tea'; but neither the features nor their names have any significance for botanical nomenclature, nor can they be significantly associated with differences in the manufactured product. As such names are not associated with specific seed sources, they are less useful than trade or *jat* names.

Attention is now being directed to more precisely defined sources in which seed is obtained by the cross-breeding of specially selected clones. Clones are also being used experimentally in lieu of seed, for growing special kinds of tea.

CHAPTER 42

RUBBER

RUBBER is obtained from the latex or milky fluid exuded by a number of plants when they are cut or bruised. These plants comprise large trees, giant creepers, and low-growing shrubs. However, the most important source of rubber is *Hevea brasiliensis* or the Para-rubber tree. This tree is a native of Brazil where it grows wild in the forests lying on both sides of the lower reaches of the Amazon river, particularly in the province of Para from which it derives its name. It is now cultivated extensively in India, Ceylon, Burma, Malaya, Singapore, Borneo, Java, Sumatra and many South Sea Islands, West Africa, South America, Venezuela, Ecuador, Colombia and the West Indies. The cultivation of the rubber tree started in India only towards the beginning of the present century, but it has already become an important and flourishing enterprise. Rubber plantations now cover large areas, chiefly in South India. Kerala, Madras and Mysore are the most important centres of cultivation.

The total area under rubber and the total production of raw rubber in 1958 were as follows

State	Area (acres)	Production (tons)
Kerala	2,70,625	22,159
Madras	11,581	1,724
Mysore	3,939	430'
Andamans	422	15
Total ..	2,86,567	24,328

The Para-rubber tree grows most satisfactorily at altitudes ranging from sea level to elevation of 1,000 feet. In India, it occupies mostly the hilly country lying on the slopes of the Western Ghats below 1,000 feet. For the successful cultivation of it a minimum annual rainfall of 80 inches well distributed over the whole year is necessary, while a heavier rainfall of even 120

inches is not harmful. It requires an equable temperature around 90° F. and humid conditions. Extreme seasonal variation, particularly in temperature and dry conditions, would affect the yields adversely.

The tree can be grown on a variety of soils ranging from fine alluvial deposits to laterite. In India most of the plantation soils are reddish lateritic soils or clayey soils.

CULTIVATION

The tree is propagated both by seed and vegetatively by means of budding.

The fruit of the tree is a three-lobed capsule which contains three small rounded seeds with hard smooth mottled testa. The seed does not remain viable for long and is, therefore, sown as soon as possible after being gathered from July to September. Special care is taken to collect it only from selected areas planted with clones known and proved to be good seed parents. It is sown in nurseries. When the stem of the seedlings attains a diameter of about 3/4 inch or more at the collar, they are stumped at a height of 18 to 24 inches and transplanted in the field.

For propagation by budding, only trees of proved outstanding performance are selected as mother trees. Plantations of budded trees yield twice or thrice as much rubber as the ordinary seedling trees. Budding is, therefore, becoming a general practice. It is carried out in the nursery or on stocks grown for this purpose in the field.

After planting (about 180 trees per acre is the initial optimum number), a leguminous cover crop is established for soil conservation. When the seedlings are well established, usual cultural operations such as weeding, digging and manuring are carried out regularly. Rubber growing on impoverished soils requires an organised programme of manuring with well balanced manure mixtures. The present official recommendations of the Rubber Board are: an 8-12-12 mixture for young rubber and 8-10-12 mixture for mature trees. Fertilizers which form residual alkalinity in the soil such as sodium nitrate are not used in rubber fertilizer mixtures.

Tapping of Rubber. The tapping of rubber is started when the trees have attained a girth of 20 inches or more, at a height of 40 inches above ground level. Under the climatic conditions obtaining in India, this is reached in the seventh or eighth year after planting. Earlier tapping would affect the health and longevity of the tree adversely. For convenience, tapping cuts are opened at a height of about 40 inches from the ground. Tapping is usually done on a spiral cut extending over half the circumference of the tree on alternate days.

The bark is cut close enough to the cambium to tap the maximum number of latex-vessel rings without injuring the cambium. The cut is made with special knives, the layer pared off being very thin so that a month's tapping removes only about half an inch of the bark. The latex which flows out, is collected in cups fitted below the lower end of the spiral cut.

In India tapping is suspended for four to six weeks during the leaf fall or 'wintering' during January to February as the yields fall very low during this dry period. It is resumed when the refoliation is completed. In some localities where the South-West Monsoon is very heavy and continuous, it is impossible to tap the trees during the peak of the monsoon. They are, therefore, rested in such localities for one to two months. The number of tapping days in the year vary from 200 to 300 days in various planting districts.

Preparation of Rubber. The preparation of rubber on the estate is carried out in three stages, viz., (i) coagulation, (ii) pressing, and (iii) smoking and drying. The fresh latex is allowed to coagulate, by adding and mixing thoroughly measured quantities of formic acid or acetic acid. The coagulum contains rubber as well as some water and impurities. It is washed in water and then passed through a roller press to get rid of most of the water and dissolved impurities. This is followed by the smoking and drying process. The resulting product is the brown plantation "smoked sheet" rubber which is sent to factories. Rubber is also marketed in the form of preserved, normal and concentrated latex, crepe rubber and sole crepe rubber. The yield from ordinary seedling trees is about 30 lb. per acre, per annum and that from budded and clonal seedling trees is about 700 to 800 lb. In some countries yields as high as 1,500 lb. per acre have also been obtained.

VARIETIES

The Para-rubber tree belongs to the natural order Euphorbiaceae, which comprises many tropical trees, shrubs and herbs. The genus *Hevea* itself includes several species, though *Hevea brasiliensis* is the main source of all the Para-rubber of commerce. There is a very large number of strains of this species which differ not merely in the yield of rubber but also in other characters such as vigour, rate of growth and bark renewal, susceptibility to diseases, etc. Some of the more important clones used for budding the plants in India are: AVROS from Sumatra; Bodjong Datar, Tjirandji and Djasinga from Java; and Prang Besar, Sabrang, Rubana, Glenshiel from the estates in Malaya. Recently, proved and promising clones developed by the Rubber Research Institute of Malaya have been introduced for experimental planting by the Rubber Board.

CHAPTER 43

CINCHONA

CINCHONA is a genus. of about 65 species of evergreen shrubs and trees. It is indigenous to South America and occurs in the Andes, Colombia, Ecuador, Peru and Bolivia, between 10° 1V. and 19° S. at altitudes ranging from 2,500 to 9,000 ft. Some species are also cultivated in Java, Ceylon, India, Burma, Tanganyika and other countries.

The pre-war production of cinchona anti-malarials in India was about 70,000 lb.,. and about 1,30,000 lb. were imported. The imports decreased considerably during the war and the indigenous production increased to about 1,78,000 lb. ~ The production has since been reduced and it is only about 75,000 lb. per annum in the Madras State at present.

CULTIVATION

Cinchona requires an elevation of 3,500 to 8,000 feet for optimum performance. It grows at lower altitudes also but the plants there are attacked by diseases, and the yield of quinine from them is also low. On elevations of over 6,000.feet, the growth is slow. None of the commercial cinchona species is frost resistant. A fairly high average temperature (60° to 70°F. with small variations), high atmospheric humidity, and heavy rainfall (100 to 150 inches), well distributed over the year, are necessary for good growth. The crop flourishes best in light, well drained virgin forest soils, rich in organic matter. There should be no water-logging of the sub-soil. Sloping situations protected from high winds are ideal for raising a plantation.

In some regions of Madras, cinchona. is known to grow even where the annual rainfall is about 45 inches. But, under such conditions the growth gets stunted and the alkaloid content of the bark also falls low. When grown on porous, well-drained soils with a gentle slope, the plants are able to withstand an

annual precipitation of up to 200 inches, provided the rainfall is well distributed over the whole year.

Cinchona can be propagated either through seed or by vegetative methods. The latter give better results. In India, however, it is commonly propagated through seed as this method is comparatively less expensive and seeds of the best strains are also easily available.

Harvesting of the bark begins from the year when the annual thinning becomes necessary. The alkaloid content in the bark is maximum when the plants are 10 to 12 years old. The branches of the trees are removed and the stems pruned off about 5 feet from the ground. The stumps are dug out, roots cleaned, and the bark removed with a bone-knife after it is loosened by tapping. The bark thus obtained is dried under shade. Under rainy conditions, drying is carried out in special sheds or by using artificial heat. Care is taken not to export the bark to- a temperature higher than 175.° F.

SPECIES

Among the cultivated species, *C. calisaya*, *C. ledgeriana*, *C. officinalis* and *G. succirubra* are the important sources of commercial cinchona bark.

C. calisaya Wedd., yields the Yellow Peruvian or Calisaya bark of commerce. It thrives at altitudes ranging from 1,500 to 3,000 feet and is found in the Moyar Valley in the Nilgiris and in Sikkim.

C. ledgeriana Moens, is considered by some to be a variety of *C. calisaya* and is the source of ledger bark. It flourishes at altitudes of 3,000 to 6,000 feet and is the principal variety grown in Bengal. It is also grown on the Annamalai Hills and in Tirunelveli district in South India. Its plantations also exist at 5,000 ft. elevation in the Khasi and Jaintia Hills in Assam. Its bark is a rich source of quinine (up to 14 per cent). It forms 75 per cent of the cinchona -trees in Indian plantations despite the fact that the species is difficult to rear.due to its exacting requirements.

C. officinalis Linn. syn. *C. condaminea* Homb. and Bonpl. yields the Crown or Loxa bark. It flourishes at elevations of 6,000-8,000 feet, and is found growing in Ootacamund.

C. succirubra Pav. X Klotzsch, is the commercial source of red bark. Adaptable to varying altitudes, from 2,000 to 6,000 feet,

this species is the hardiest and most easily cultivated. It is grown in South India, Sikkim and the Satpura range in Central India.

Besides these species, there are certain hybrids which are ~ quite promising. *C. hybrids* or ledger hybrid (*C. ledgeriana* X *C. succirubra*), is hardier than *C. ledgeriana* and is found cultivated in some parts of Bengal. *C. robusta* (*C. officinalis* X *C. succirubra*) is another hybrid which forms 22 per cent of the trees in Indian plantations. It is grown at Naduvattam in Madras at an altitude of 3,000 to 6,000 feet. Another hybrid (*C. officinalis* X *C. ledgeriana*) is grown in Mungpoo.



FIG. 38. A cinchona plantation



FIG. 39. Brood lac



FIG. 40. Stick lac

CHAPTER 44

LAC

THE cultivation of lac in India is very ancient. References to it are found in Atharv Veda, in which it is termed Laksha. Its trade with the western world began with the lac dye in the seventh century and the dye trade flourished till the middle of the 19th century from when it started gradually going out of existence. Meanwhile export of shellac from India expanded enormously towards the end of the last century because of its use in the manufacture of phonograph records, French polishes, electrical industry, etc. Shellac is indeed a multi-purpose resin, and has contributed materially to the progress of science and industry. It is used extensively in the preparation of moulding compositions, varnishes, paints, lacquers, adhesives and cements. Till recently, it occupied about the tenth position in our export list, and earned annually for the country about eleven crores of rupees in foreign exchange.. At present the value of lac exported is in the region of eight to ten crores of rupees annually. Besides, it is an important source of subsidiary income in the rural areas. The production of stick lac in 1958-59 was as follows

State	Production (md.)
Assam	10,000
Bihar	4,28,000
Bombay	72,000
Madhya Pradesh . . .	3,92,000
Orissa	21,000
Uttar Pradesh	15,000
West Bengal	61,000
Other Indian States . .	5,000
Total . .	10,04,000

Lac is a resinous secretion from the hypodermal glands of a scale -insect called *Laccifer lacca*, Kerr. The insect thrives

(as a parasite) on certain species of plants called lac hosts, whose sap is the food of the insects. The, young crawling larva. emerging from the mother cell settle on succulent twigs by inserting its proboscis into the bark of its host and goes on sucking sap and secreting lac all round its body till it dies: lac really forms a protective covering for the insect. The insect is sedentary in its habit, and the female larva once having settled at a spot does not show any further movement and spends its entire life in the lac cell built by its own secretion. The male larva, on the other hand, spends its life within the cell till the Ault stage is reached, when it comes out in search of females in order to fertilize them. The cells, however, lie very close to one another and generally coalesce to present the appearance of continuous lac encrustation. It is obvious that lac cultivation is really the rearing of these insects generation after generation.

Two distinct strains of the lac insect are recognised, namely, the Kusmi and Rangeeni; the former living and thriving mostly on Kusum (*Schleichera oleosa*) and yielding superior quality resin and the latter on hosts other than Kusum, namely Palas (*Butea monosperma*), Ber (*Zizyphus mauritiana*), Ghont (*Zizyphus zylobyra*), Tallari (*Shorea talura*), Arhar (*Cajanzcs cajan*) and a few *Ficus* species. Khair (*Acacia catechu*) can sustain either strain and has been found suitable both for Aghani and Katki seasons. Recently, Bhalia (*Moghania macrophylla*) a natural bush has been found to be a very suitable alternative host for the Kusmi strain for growing the superior quality lac under agricultural conditions and with reduced cost of cultivation. Both the strains complete two life-cycles per year (with the exception of Rangeeni strain on *Shorea talura* in South India, which completes three life-cycles in about 13 months, but behaves normally on the same host in Chotanagpur), and corresponding to each life-cycle one lac crop is obtained: there are, therefore, four lac crops a year, two Kusmi, and Rangeeni: while the two life-cycles in the case of Kusmi are more or less of equal duration, those for Rangeeni are very unequal, one being nearly double the other. The two Kusmi crops are Gethroi (January-February to June July) and Aghani (June July to January-February), and Rangeeni crops are Baisakhi (October-November to June July) and Katki (June July to October-November).

It is clear that successful lac cultivation requires study of, and attention to : (1) the insects which have to be reared in a healthy condition, (2) the host trees which are to provide food and shelter to them, and (3) the enemies, particularly insect enemies, which have to be controlled. Inclement weather is also a great deterrent to lac insects and has to be guarded against or circumvented by some means.

CULTIVATION

Each female inhabiting a cell, when -mature, lays eggs inside the lac cell in a cavity, created by withdrawing a portion of its body, which hatch to give rise to larvae. These larvae, start coming out through the anal opening of the lac cells. Each female may give rise up to some 1,000 larvae, the average number being 200 to 500 per female. Sexes in the progeny are usually in the ratio of the one to two females. Since a lac-encrusted stick, even if only a few inches long, will contain a large number of cells, the number of larvae emerging is enormous and covers the stick as a crimson powdery fluff made up of minute soft-body creatures (0.6 mm. long and 0.2 mm. across) crawling all the time in search of new habitat. This largescale emergence of larvae from the lac stick is called swarming and the lac sticks in which swarming is taking place or is about to take place are called brood lac. Lac cultivation involves tying sticks of brood lac on to branches of (prepared) host trees, on which the larvae coming out of their mother cells; settle and start a new generation. This tying of brood lac to fresh hosts is called 'infection' or 'inoculation'. Brood lac is the most important item in lac cultivation, and unless it is mature and healthy, the progeny are weak and devitalised, so that they either do not survive or produce very little lac. Therefore, brood lac should be cut from the trees only when mature, i.e., just a few days before larval emergence starts. Since the brood lac cannot be kept long, it should be used up for inoculation immediately. It is kept on the tree for the minimum period (about three weeks) required for all the emerging larvae to crawl out, and then the phunki (empty brood lac sticks) is removed and the lac is scraped off. The larvae, settled on the trees, grow up and when they are mature again, they are ready to be reaped. In an average crop the yield

is about three to five times the amount of brood lac used for inoculation.

For systematic and sustained production of lac, the host trees should be pruned properly and in time prior to inoculation, so that adequate food supply to the lac insects is ensured when the trees are inoculated. Appropriate time for pruning Rangeeiai hosts like Palas and Ber is about the middle of February for raising the liatki crop; and it should be about the middle of April for the Baisakhi crop. In the case of Kusum trees, they are pruned only initially about 18 months prior to inoculation and thereafter the harvesting of crop will serve the purpose of pruning as well. This naturally involves working the lac-host trees on a coupe system, so that while trees in a certain coupe are under inoculation, others in other coupes receive rest as also the pruning treatment.

It is also necessary to see that correct amounts of brood lac are used for, inoculation to ensure successful lac crops. Usually, the brood rate to be used should be such as to give continuous and satisfactory settlement of lac larvae over about 15 times the length of twigs as compared to the length of brood lac, sticks. For the Baisakhi crop, however, the rate should be reduced so that the sparse settlement resulting therefrom is helpful for better survival of brood lac during the summer.

The lac insects die in large numbers in the summer season from April onwards, particularly on the Palas and Ber trees in the Baisakhi crop. The ,fethwi crop does not suffer so much, since Kusum which is an almost evergreen tree provides adequate food supply and protection from heat, to the lac insects. Therefore, in order to produce sufficient brood lac in the Baisakhi season, it may be found desirable to inoculate the trees lightly at the time of inoculation, so that the brood survival is better even though it is at the cost of crop production to some extent. Alternatively, host trees such as Albizzia lucida, Ougeinia dalberjoides and Ficus cunia, which are known to be better brood preservers, may be exploited in addition to the conventional lac hosts to supplement brood production on the latter.

Insect enemies of lac account for 30 to 40 per cent loss of the total crop. These are of two kinds, parasites and predators. The former are Claalcsids, which lay their eggs into the

body of the lac insect: the larvae of these feed on and kill the insects eventually. The damage to lac cells by these parasites is considerably less as compared to that by predators. The most important predators are the larvae of *Eublemma amabilis*, a white moth, and *Holcocera pulverea*, a blackish grey moth. Methods, both cultural and artificial, have been devised to control these pests.

CHAPTER 45

FRUIT CROPS

THE estimated, total area under different fruits in India is about 28,66,000 acres, or 0.8 per cent approximately of the total cropped area. This is very small compared to the total population in the country. To every acre under fruit trees there are 145 persons. The relative position in some advanced countries is very much better. In Palestine, for instance, the corresponding average is 7, and in California (U.S.A.), it is only 3. It is true that the entire horticultural produce in Palestine and California is not meant for internal consumption, but these statistics reveal the importance attached in those countries to horticulture, which is much more remunerative than other branches of agriculture.

The total estimated production of fruits in India is about 195 million maunds or nearly seven million tons, of which a substantial proportion is wasted at various stages of marketing. Allowing further for stones, peels, etc., the quantity available for actual consumption may not be more than a hundred million maunds. This works out to about one ounce per individual per day: The normal daily requirement of an individual according to nutritional standards is two ounces. In most of the advanced countries, the consumption is much more than the basic requirement. In New York, for instance, it is 16 oz. per head per day, and in London it is 4.5 oz. Again, consumption in our country-low as it is-is confined mostly to the urban sector, while people in the villages, who form the bulk of the population, hardly take any fruit excepting the desi mango. All this shows that production has to be increased considerably to meet the basic requirements of the nation..

From the economic point of view, too, fruit growing is of considerable importance. The holdings in India are smaller than those in most other countries. With a small area devoted to the growing of fruits, the farmer can earn a better living than by putting it under farm crops.

India has been the home of some of the world's most famous fruits. In the Himalayas, the wild species of strawberry,

raspberry, pear and apricot are frequently met with. The commercial variety of apple called 'Ambri' originated in this region and is now largely grown in the Kashmir Valley. In the Himalayan foot-hills originated the golden coloured citrus fruits, whence they spread to far off places in the Mediterranean countries and the Americas. The mango, the pride fruit of India, also originated here.

According to their natural distribution, the various kinds of fruits are broadly classified as temperate, sub-tropical and tropical. This classification is helpful in indicating the situations likely to be suitable, for the growing of fruits belonging to each of the three groups.

A particular fruit grows best under conditions very similar to those in which it originated in nature. It is, however, possible to evolve varieties and develop cultural practices that would make its cultivation successful under varying conditions. For instance, we have evolved a technique of pruning grapes that enables it to grow successfully even under tropical conditions. In spite of the climatic limitations, the yield and quality of grapes produced in southern India are in no way inferior to those reported from sub-tropical parts of the world where grape cultivation is concentrated.

Some fruits are known to thrive well under different climatic conditions without any special treatment. Their wide range of adaptability has been due to the large number of varieties originating from time to time under diverse climatic conditions. The varieties thriving in one region may not, however, do equally well in another region where the natural conditions are markedly different. Thus, the South Indian mangoes do not thrive in the northern region, and vice versa.

For a country of the magnitude of India where the same fruit is grown to perfection in different regions under different climatic conditions, it would be desirable to know something of the climate and soils of each region as also of the fruits and their varieties adapted to those conditions. This information is, therefore, briefly given below.

I. HIMALAYAN TEMPERATE REGION

This region extends from Assam in the Eastern Himalayas to the Kashmir Valley in the Western Himalayas. Places where temperate fruits are grown include parts of Assam, Kumaon Hills (U.P.), Himachal Pradesh, Punjab Hills, Kulu Valley and Kashmir Valley.

The soils of this region consist mainly of folded sedimentary rocks or residual soils derived from these. The rainfall varies considerably-the average for the eastern parts being 80 inches and for the north-western region being less than 25 inches. Thunder and hailstorms are frequent in many parts in March and April, though occurring occasionally in May and June as well between long spells of hot dry weather. The rains are abundant in July and August when the humidity remains high. The middle of September usually marks the end of the rainy season. Winter months witness occasional snowfall and hailstorms. January is the coldest month, when the average daily temperature remains below 40° F. July is the hottest month of the year, but the average temperature seldom rises above 70° F. in the western portion, and 80° F. in the eastern parts. The driest months are December and early part of June.

In the Sutlej Valley beyond the Wangtoo bridge as also in the Baspa Valley, the precipitation is comparatively very low and the summers are sunny, warm and dry. This tract is famous for chilgoza cultivation; and the quality of this fruit is superior even to that imported from Afghanistan. The juicy varieties of grape are also grown here on a small scale-more for preparing liquor than for fresh consumption. The climatic conditions are pre-eminently suitable for horticulture, and are ideal for the development of raisin industry. Wild apricots are planted on the borders of fields. The pulp is dried for local consumption, and the seed is milled for oil which is used for culinary purposes.

In Himachal Pradesh, the Punjab, Kumaon Hills and the Valleys of Kulu and Kashmir, all kinds of temperate fruits are grown to perfection. The rainfall here is quite adequate for the successful cultivation of these fruits, but at lower altitudes irrigation has to be provided in the summer season. Most of the cultivated varieties grown in this region were introduced from foreign countries like the U.K., the Continent, and the U.S.A., by the European settlers and missionaries, prominent among whom

were S. N. Stokes, Alexander Coutts and Lee. There is tremendous scope for expansion of the cultivation of temperate fruits in these areas, but the main bottle-neck has been inadequate transport. Considerable amount of fruit is wasted when heavy monsoons cause road breaches, and trans-shipment to the consuming centres is withheld. The cultivation of soft fruits like strawberry, raspberry, currants, etc., has not developed for want of proper marketing facilities. The most promising and successful varieties of fruits grown in the region are mentioned below:

Name of fruit	Varieties successfully grown	Places where grown
Apple	Red Delicious, Golden Delicious, King of Pippins (No. 13), Starking (Royal) Delicious, Cox's Orange Pippins, Worcester Pearmain, Richard and Newton Wonder.	Himachal Pradesh
	Ambri Kashmiri, White Dotted Red, Blood Red, Baldwin, Red Delicious.	Kashmir Valley
	Early Shanbury, Red Astrachan, Lady Sudley, Red Delicious, Beauty of Bath, Jonathan, Rome Beauty, Stayman Winesap, Winter Banana, Yellow Newton.	Punjab Hills
	Blenheim Orange Pippin, Delicious, Early Shanbury, James Grieve, Jonathan, Rome Beauty, Winter Banana, Golden Pippin, King of Pippins, Rymer.	Kumaon Hills (U.P.)
	Red Astrachan, King of Pippins, Yellow Newton, Ben Davis, Red Delicious, Cox's Orange Pippin, Blenheim Orange, Baldwin, Golden Delicious, Granny Smith.	Kulu Valley Punjab

Name of fruit	Varieties successfully grown	Places where grown
	Rome Beauty, Glengyle Red.	Nilgiris and the South
	William's Favourite, James Grieve, Prince Albert, Lady Sudley, Charles Ross.	Assam
Pear	1. Williams Bon Chretien (Bartlett) 2. Clapp's Favourite 3. Thompsons 4. Doyenne du Comice 5. Easter Beurre 6. Winter Nelis 7. Conference 8. Dr. Jules Guyot 9. Marie Louise d'Uccle 10. Baghu Gosha (Citron de Carmes) 11. Emile d'Heyst	Elevations above 5,000 feet
Cherries	1. Early Rivers 2. Governor Wood 3. Bigarreau de Schrecken 4. Elton 5. Bedford Prolific 6. White Bigarreau 7. Monstrueuse de Mezel 8. Bigarreau Napoleon 9. Emperor Francis 10. Late Black Bigarreau	Elevations above 5,000 feet
Peach	1. Early Beatrice 2. Alexander 3. Early Rivers 4. Duke of York 5. Peregrine 6. Noblesse 7. Late Devonian 8. Elberta 9. J. H. Hale 10. Triumph 11. Alton 12. Prince of Wales	Elevations between 3,500 to 5,000 feet
Plum	1. Grand Duke 2. Bright Red Burbank 3. Early Transparent Gage 4. Victoria 5. Santa Rosa 6. Wickson	Elevations between 3,500 to 5,000 feet

Name of fruit		Varieties successfully grown	Places where grown
		7. Beauty 8. Kelsey 9. Dorris 10. Satsuma 11. Burbank 12. Hall	
Apricot	..	1. Shipley Early 2. Kaisha 3. New Castle 4. St. Ambroise 5. Royal	Elevations between 3,500 to 5,000 feet
Strawberry	..	1. Trafalgar 2. Laxton's Latest 3. The Laxton 4. Royal Sovereign 5. Early Cambridge 6. Huxley Giant	Elevations between 3,500 to 5,000 feet
Persimmon	..	1. Fuyu 2. Hachiya 3. Hyakume	Elevations between 3,500 to 5,000 feet
Grape	..	1. Thompson's Seedless 2. Sultana 3. Kishmish White	

Under the warm temperate conditions at elevations varying from 3,500 to 5,000 feet, stone fruits and nuts, like peaches, plums, apricot, walnut and pistachio grow better than pome fruits like apple and pear. However, at higher elevations in the warm temperate regions, pome fruits also grow quite successfully. Other fruits such as the loquat and hill lemons are also likely to grow well in the warmer tracts.

II. NORTHERN DRY REGION

This region includes the plains of the Punjab, the western districts of Uttar Pradesh, western Madhya Pradesh and Rajasthan. These tracts have a fairly wide range of climate arid soil conditions comprising as they do, sub-mountainous regions as well as the vast plains and desert areas. The sub-mountainous tracts have elevations varying from 1,500 to

1,000 feet, where winter is distinctly more severe than in the plains. The whole of this region is, however, characterized by much higher temperatures in the cultivation season. The stormy winds blow in summer before the onset of rains. The rainfall varies from 20 to 35 inches; and artificial irrigation has to be resorted to for successful fruit production. In the desert areas, the rainfall varies from 5 to 25 inches. Because of a fairly wide range of climatic conditions, all sub-tropical fruits-both the deciduous and, the evergreen types-are successfully grown in this region. They comprise citrus fruits, date, fig, guava, passion fruit, grape, jujube, loquat, litchi, mango, olive, papaya, pecan, phalsa, pomegranate, persimmon, pear, peach, almond, plum and sapota.

The cultivation of almond, persimmon, pecan, pear, peach, plum, loquat, fig and passion fruit is successful at higher elevations in the Punjab, Himachal Pradesh and Uttar Pradesh. The climate of Saharanpur and Dehra Dun districts of Uttar Pradesh enjoys the marginal- advantages of sub-mountainous and warm temperate climate, enabling fruits adapted to

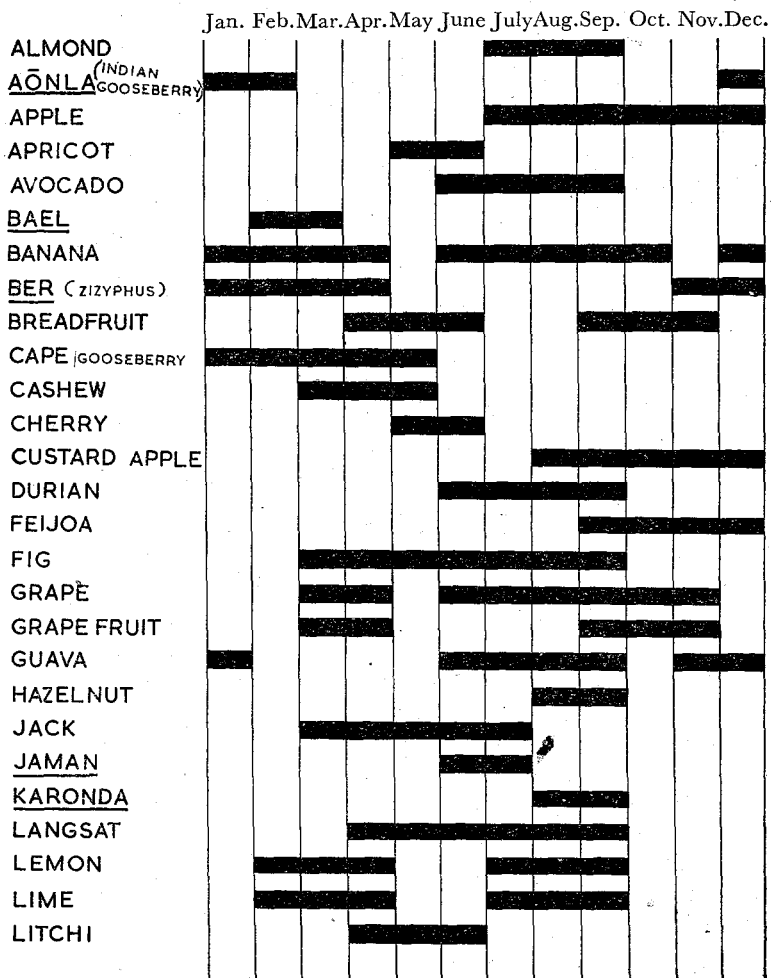


FIG. 41. Harvesting seasons of different fruits grown in India

Both the regions to 1 grow quite successfully. The fruits grown at Saharan-pur are the peach, plum, persimmon, loquat, citrus fruits, mango, litchi, Phalsa, sapota, papaya, guava and banana. The European grapes can grow successfully under varied conditions, the only limiting factor being the onset of early rainfall in summer. The varieties ripening earlier than the end of June alone have a chance to grow well. The most suitable tracts in this region for grape cultivation appear to be the districts of Hissar and

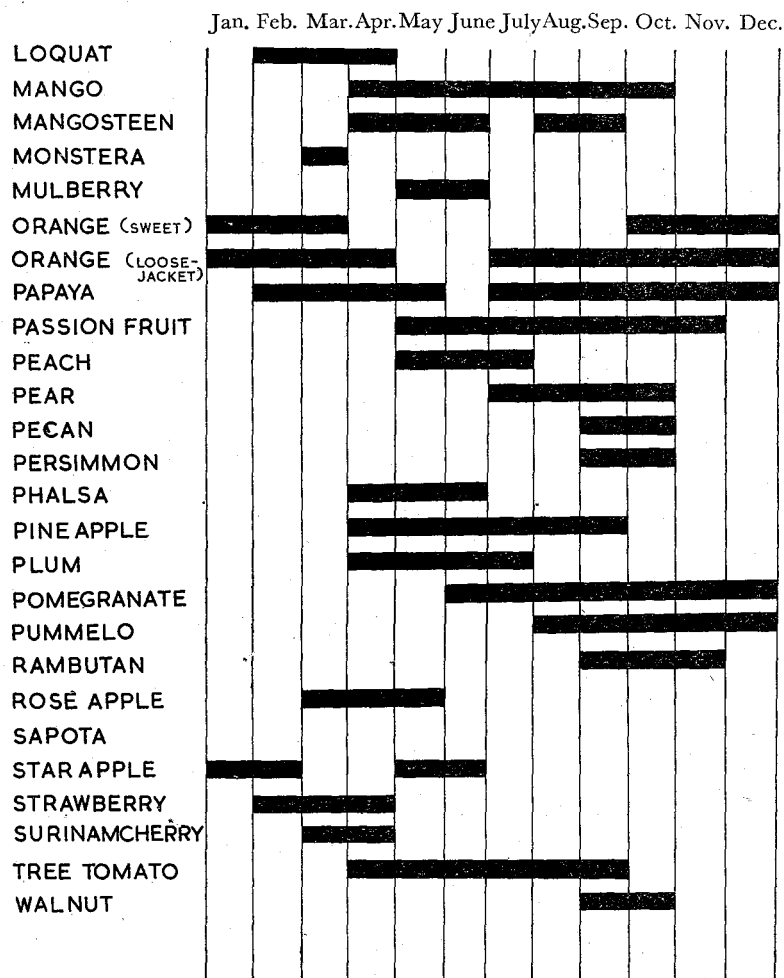


FIG. 42. Harvesting seasons of different fruits grown in India

Ferozepur in the Punjab, and the northern districts of Rajasthan. The Arabian dates are also expected to grow quite successfully in the tracts mentioned suitable for grape-vine cultivation. Of the citrus fruits the tight-skinned orange (Malta) should be grown in the plains of the Punjab,

western U.P., and northern Rajasthan. Santras of excellent quality. are grown in Madhya Pradesh. Banana is a tender

tropical plant and suffers badly from winter frosts and dry summers. The leading commercial variety of banana, i.e., Basrai, is extremely susceptible to frost, and is much more tender than the other varieties grown in this region. The phalsa and jujube would thrive even in impoverished lands, and are also fairly drought resistant. The guava can grow anywhere except in the frosty situations, and can withstand stagnant water conditions for a period of two to three months.

Fruits and their varieties which have proved successful in this region are as follows

Name of fruit	Varieties	Place of cultivation
Mango	(i) Dusehri, Langra, Samarbehist Chowsa, Safeda Lucknow, Safeda Malihabad, Bombay Green, Bombay Yellow, Fajri Zafrani, Gopal Bhog, Fajri, Rataul, Sehroli, Malda Handel, Yakutia (Hushnara), Baramasia (all the year round) (ii) Dusehri, Langra, Malda, Sindhuria, Seedling mangoes and Sehroli	Grown extensively in the central and western districts of Uttar Pradesh especially in Kanpur, Lucknow Meerut, Saharanpur, Bareilly and Hardoi districts Mainly grown in Hoshiarpur, Ambala, Gurdaspur, Karnal districts of the Punjab and Delhi
Citrus fruits	1. MANDARINS (Santra) (i) Desi, Nagpur, Emperor and Laddu (ii) Desi, Coorg, Naartjee, Lahore Local (iii) Nagpur 2. TIGHT SKINNED ORANGE (Malta) (i) Mosambi, Blood Red, Jaffa, Washington Navel, Vanielle, Common, Early Blood, Joppa, Firefly Navel, Majorca, Tardiff, Mediterranean Sweet (ii) Blood Red, Pineapple, Hamlin, Jaffa Common, Valencia Late 3. ACID AND SWEET LIMES <i>Kagzi Nimbu</i> and Sweet Lime	Desi seedlings mostly in Kumaon sub-mountainous tracts and Saharanpur and Dehra Dun districts in Uttar Pradesh Desi mostly in the hills near Pathankot and Himachal Pradesh, other mostly in the Punjab In north-western districts of Madhya Pradesh Mostly grown in Saharanpur and Meerut districts of Uttar Pradesh All over the Punjab Saharanpur and Meerut districts of Uttar Pradesh and to certain extent in sub-mountainous tracts of Himachal Pradesh; grown also in Kumaon Hills; grown also in Himachal Pradesh and the Punjab

name of fruit	Varieties	Place of cultivation
4. LEMONS		
	<i>Baramasia</i> , Eureka, Villafranca, Ponderosa, European, Hill Lemon (galgal)	Mostly in parts of the Punjab and Uttar Pradesh
5. GRAPE FRUIT		
	(i) Saharanpur Local, Marsh Seedless, Triumph, Duncan	Mostly in Saharanpur and Meerut districts of Uttar Pradesh
	(ii) Marsh Seedless, Foster, Duncan, Poona Budded	Punjab
6. PUMMELO		
	Red Fleshed and Gills Jeolikote	Western districts of Uttar Pradesh and Punjab
ate	.. Hillawi, Khudrawi, Shamran and Zaidi	Western districts of the Punjab and north-western Rajasthan
g	.. Black Ischia, White Fig and Poona Fig, Brown Turkey	Successful in U.P., Rajasthan, and parts of the Punjab
lava	.. Safeda, Hafzi, Lucknow 49, Seedless, Karela	Grown mostly in U.P. and to a certain extent in the Punjab
andilla (Passion Fruit)	Selections from Palampur and Saharanpur	Localized in Saharanpur and Chakrata in U.P. and Palampur in the Punjab
ape	.. Thompson Seedless, Black Prince, Dakh, Khalili, Foster's Seedling and Muscat of Alexandria	Mostly in the Punjab and certain parts of U.P.
ube	.. Local selections of round and large varieties; large fruited Nazook, Bedana and Benarsi	Punjab, Uttar Pradesh and Rajasthan
quat	.. Golden yellow, Pale Yellow, Large Agra, Fire Ball, Tanaka, Thames Pride, California Advance	Mostly grown in western parts of U.P. like Saharanpur, Meerut and Dehra Dun districts and Gurdaspur district in the Punjab
chi	.. Early Bedana, Late Bedana, Desi variety, Seedless Dehra Dun, Rose Scented, Late Large Red, Calcuttia	Mostly in Saharanpur and Dehra Dun districts of U.P. and Gurdaspur district in the Punjab
paya	.. Honey Dew, Washington and Saharanpur selections	Common in U.P. and the Punjab and parts of Rajasthan
can	.. Mehan, Success, Nellis and Halbert	Grown in the sub-mountainous tracts of U.P., Himachal Pradesh and the Punjab
alsa	.. Local selections	Common all over
negrinate	Kabuli, Kandhari, Paper, Shell, Muscat Red	Found all over
simmon	Fuyu, Tanenashi, Hachiya	Grown in U.P. and the Punjab

Name of fruit	Varieties	Place of cultivation
Pear ..	Leconte, Baghu Gosha, China, Country pear, Kieffer, Bartlett	Grown in western parts of U.P., Himachal Pradesh, the Punjab and Delhi
Peach ..	Bidwill Early, Slipstone, Early Cream, Dr. Hogg, Early Agra, Elberta, Early Crawford, J. B. Hale, Alexander, Waldo, China Flat	Mostly cultivated in western districts of U.P., Lucknow, the Punjab Hills, Jaipur in Rajasthan and Jammu
Plum ..	Early Large Red, Japan Gold, Kabul Greengage, Alubokhara, Large Yellow, Rubio, Alucha Red, Sharp's early Shalimar, Kelsey, Burbank, Satsuma, Czar, Jefferson, Victoria, Damsons, Clyman	Mostly grown around Chaubatia in U.P., in Punjab Hills and Himachal Pradesh
Sapota ..	Round Oval, and Saharanpur selections	Cultivated in some districts of U.P. and around Jaipur in Rajasthan

III. EASTERN WET REGION

This region comprises the southern parts of Assam, West Bengal, Bihar, Orissa, eastern Madhya Pradesh, eastern Uttar Pradesh, and north-east Andhra. The soils of this region consist mainly of alluvium--red and yellow loam and sandy foams. Assam is mostly made up of the Brahmaputra alluvium, except for some patches of reddish brown soils derived from rocks. The coastal part of Orissa consists of coarse alluvium, but elsewhere the soils are red to yellow foams. The eastern districts of Madhya Pradesh have a mixture of red and yellow foams, and black sandy and black loamy soils. The eastern districts of Uttar Pradesh and most of Bihar and West Bengal are wholly made up of the Gangetic alluvium.

The rainfall in this region varies from 30 to 75 inches--exceeding 75 inches only in Assam and parts of West Bengal. The winters are mild with a temperature of 70°F. in the coolest month (January). Growing season temperatures are high--ranging from 90° F. to 100° F. High and dessicating winds are experienced in some parts before the beginning of rains. Fruit growing cannot be undertaken successfully unless the rainfall is supplemented with artificial irrigation. The fruits grown are the mango, citrus, guava, banana, sapota, cashew, pineapple, litchi, papaya, jack, chiku, custard apple and pear.

The varieties most successfully grown along with their places of cultivation are mentioned below:

Name of fruit	Varieties	Place of cultivation
Mango	(i) Bombai, Fazli Malda, Safeda Calcutta, Himsagar	Grown intensively in Burdwan, Hooghly, Murshidabad, Malda and 24-Pargana districts of West Bengal
	(ii) Bihar Alphonso, Langra, Gulab-khas, Kishen Bhog, Zardalu, Mithua, Kaithki, Khas-ul-khas, Sukul	Chiefly grown in Muzaffarpur, Darbhanga and Bhagalpur districts of Bihar

name of fruit	Varieties	Place of cultivation
	(iii) Langra, Shadwala, Shahpasand, Sakkarchina, Brindabani, Fajri, Safdar Pasand, Dusehri, Smarbehisht Chowsa, Taimuria, Bombay Yellow, Budu-ka-kelwa	Mostly in eastern districts of U.P., viz., Allahabad, Bara Banki, Fyzabad, Gonda and Sultanpur
	(iv) Mainly seedling mangoes and some varieties like Langra, Dusehri and Chowsa.	In Bilaspur, Jabbalpore, and Hoshangabad districts of Madhya Pradesh
	(v) Mostly seedling mangoes and some varieties from Andhra Pradesh like Neelum, Banganpalli, Bangalore and Dophool	Orissa
	(vi) Suvarnarekha, Rajumanu, Banganpalli, Jehangir, Pedda Rasam, Chinna Rasam, Cherukuram, Panakalu, Himayuddin, Firangiludha, Kottapalli Kobbari, and Neelum	Intensively cultivated in Godavari, Krishna and Visakhapatnam districts of north-east Andhra Pradesh
citrus	1. THE SANTRA ORANGE (Mandarin)	
	(i) Khasi Orange or Darjeeling Orange	Darjeeling district of West Bengal and Assam
	(ii) Nagpur Orange	Nagpur, Nimar district of U.P.
	2. MOSAMBI	Ranchi district of Bihar and Banaras district of U.P.
	3. KAGZI LIME	All over to a considerable extent
kuava	(i) Allahabad Safeda	Mainly grown in Allahabad, Banaras, Bareilly and Fyzabad districts of U.P., Bhagalpur, Muzaffarpur and Champaran districts of Bihar
	(ii) Hafzi	
	(iii) Smooth Green	
anana	(i) Rasthali, Martaban, Chini Champa, Jahaji, Manohar, Dig Joa, Sapri	Mostly grown in Khasi Jaintia Hills, Cachar, Kamrup and Goalpara districts of Assam and to a lesser extent in Mikir Hills, Mizo Hills, Nowgong, Sibsagar, Lakhimpur and Garo Hills
	(ii) Martaban, Singapore, Champa, Dhudsagar, Kunnan	Extensively cultivated in Malda, Murshidabad, Burdwan and 24-Parganas districts of West Bengal and also grown in Hooghly, Nadia and Bankura districts
	(iii) Malbhog, Chini Champa, Champa, Alphan, Sabja, Agheswar, Dhudsagar	Grown extensively in Muzaffarpur, Darbhanga, Bhagalpur and Champaran districts of Bihar
	(iv) Basrai, Chini Champa, Champa, Raikela	Eastern districts of U.P., viz. Allahabad, Banaras and parts of Madhya Pradesh

Name of fruit	Varieties	Place of cultivation
	(v) Mauritius (Basrai), Martaban, Champa	Orissa
	(vi) Vamankeli, Ney Poovan, Poovan, Rasthali, Martaban, Monthan, Singapore, Chakkarakeli, Nana Nendran	Extensively grown in East Godavari, Krishna and Visakhapatnam districts of north-east Andhra Pradesh
Sapota ..	Kirthiparthi (Kirtaleasti) Thagarampudi, Dwarapudi and Palasapota Jonnavalasa	Chiefly grown in Godavari, Krishna and Visakhapatnam districts of north-east Andhra Pradesh
Cashewnut	Seedling trees only	Visakhapatnam district of north-east Andhra Pradesh and Ganjam, Puri, Cuttack and Balasore districts of Orissa
Pineapple ..	(i) Giant Kew, Queen, Mauritius, Ceylon, Jaldhup	Assam
	(ii) Giant Kew, Queen Mauritius	West Bengal
Jack ..	(i) Khaja, local ordinary	Grown in eastern districts of U.P.
	(ii) Seedling trees	Grown in Santhal Parganas, Hazaribagh, Ranchi, Manbhum and Singhbhum districts of Bihar, coastal districts of Orissa and Visakhapatnam, Godavari and Krishna districts of Andhra Pradesh.
Litchi ..	(i) Early Bedana, Desi, Late Bedana, Rose, Scented, China, Muzaffarpur, Purbi	Mainly cultivated in Champaran, Muzaffarpur, Darbhanga and Bhagalpur districts of Bihar
	(ii) China and Desi	West Bengal
	(iii) Early Bedana, Early Large Red, Late Large Red, Late Bedana, Rose, Scented, Calcuttia	Eastern districts of U.P. especially extensively grown in Fyzabad district
Papaya ..	Washington, South Africa, Ceylon Round, Ranchi and Honey Dew	Grown all over the region
Ber ..	(i) Nagpuri, Thornless, Narkale, Ordinary Round	In Bihar especially in Shahabad district
	(ii) Banarasi	Mostly in Banaras district of eastern U.P.

IV. SOUTHERN REGION

The southern region consists of the southern districts of Madhya Pradesh, western Andhra Pradesh and Madras, eastern parts of Mysore, Maharashtra, Gujarat and Madhya Pradesh.

The soils of this region are mostly typical of the black cotton soils of Deccan peninsula, which is a table-land with an average elevation of 2,000 feet above sea level.. It has a gradual tilt from west to east. The soils are residual and are quite fertile, being rich in iron but deficient in humus. The soils of most parts of Mysore, Andhra Pradesh and Madras are either red or yellow loams, except for patches of black clayey soils. The rainfall varies from 20 to 50 inches, but in parts of Maharashtra it varies from 75 to 150 inches. The fruits commonly grown are mango, citrus, banana, guava, grape, papaya, fig, pineapple, custard apple, pomegranate, jack, sapota and cashew.

The different fruits and their outstanding varieties are listed below along with the tracts where they are cultivated.

Name of fruit	Varieties	Place of cultivation
Mango ..	(i) Alphonso, Pairi, Rajapuri, Kaiser	Extensively grown in Saurashtra, Baroda, and Surat districts of Gujarat
	(ii) Azum-us-Samar, Fakr-u-Samar, Langra, Dushehri, and Mulgoa	Mostly grown in Andhra Pradesh
	(iii) Bangalora, Neelum, Banganapali, Mulgoa, Allumpur Baneshan, Salem Bangalore, Suvarnarekha, Rumani, Fernandin, Jehangir, Himayuddin, Khudadad, Cherukrasam, Panakalu and Rajumanu	Chiefly grown in Andhra Pradesh, Madras and Mysore
Citrus ..	(1) ORANGE: Sathgudi, Mosambi and Batavian	Mostly grown in Aurangabad, Parbhani, Ahmednagar and East Khandesh districts of Maharashtra, Guntur, Kurnool, Cuddapah, Chittoor districts in Andhra Pradesh and Madurai district in Madras
	(2) LIME: Mostly seedlings	
	(3) LEMON: Talian, Nepali Oblong, Nepali Round, Eureka and Lisbon	
Banana ..	(i) Basrai, Safed Velchi (Ney Poovan), Lal Velchi (Poovan), Rajeli, Monthan, Sirumalai, Chakkarakeli	Mostly grown in Kolaba, East Khandesh, Parbhani and Aurangabad districts of Maharashtra; Surat and Kaira districts of Gujarat; Osmanabad and Gulberga in Andhra Pradesh, Salem and Coimbatore districts of Madras and Amraoti and Akola districts of Madhya Pradesh
	(ii) Yellakhibala, Rasabala	Mostly grown in Mysore
Guava ..	Dholka, Lucknow, 49, L. 46, Allahabad and Seedless (Arbhavi)	Mainly cultivated in Aurangabad, Bhir, Parbhani, Nanded, Nasik, Poona, East Khandesh, and Ahmednagar in Maharashtra; and Dharwar district of Mysore; Cuddapah and Kurnool districts of Andhra Pradesh
Grape ..	Bhokri, Fakadi, Pandhari Sahebi, Pachadrakashai, Anab-e-Shahi and Bangalore Blue	Mainly grown in Nasik and Aurangabad districts of Maharashtra; Hyderabad and Anantapur districts of Andhra Pradesh; Salem and Madurai districts in Madras
Papaya ..	Honey Dew, Washington, Round, Long, Gujarat	Mainly grown in Poona district in Maharashtra, Ahmedabad district in Gujarat; parts of Madras

Name of fruit	Varieties	Place of cultivation
Fig ..	Poona, Prolific, Light Purple, Penukonda, Coimbatore Fig, Daulatabad, Maisavani, Black Ischia, Brown Turkey	Grown in Anantapur and part of Hyderabad districts in Andhra Pradesh; Mysore; Poona district in Maharashtra
Pineapple	Queen, Mauritius, Dcsi, Giant Kew, Kew	Is cultivated to a limited extent everywhere especially in Baroda district in Gujarat; Madurai in Madras and parts of Mysore
Custard apple and allied species	<i>Anona squamosa</i> , <i>A. reticulata</i> and <i>A. muricata</i>	Grows in a wild condition in Andhra Pradesh, and is cultivated to a limited scale in Madurai district of Madras
Pomegranate	Dholka, Habshi, Uthukuli, Jarnohalli Michaelpatti	Cultivated on a small scale everywhere
Jack ..	Mostly seedling trees	Grown all over
Sapota ..	Round, Oval, Kalapatti, Calcutta	Is grown everywhere on a small scale; popular in Kolaba and Ratnagiri districts of Maharashtra; Baroda district of Gujarat; it is also grown in certain districts of Madras
Cashew ..	Mostly seedling trees	Is grown in Kolaba and Ratnagiri districts of Maharashtra and Guntur district of Andhra Pradesh

V. COASTAL WET REGION

This region comprises the two coastal strips in South India bordering the Eastern and Western Ghats, parts of Mysore, Madras and Kerala States.

The coastal strips are mostly composed of alluvial soils and are, therefore, the most fertile region in the South. The rainfall is heavy and the humidity remains high throughout the year. The fruits grown are mango, breadfruit, pineapple, cashew, citrus, mangosteen, banana, apple, pear, papaya and jack.

A list of the varieties of fruits grown successfully and the places of cultivation is given below:

Name of fruit	Varieties	Place of cultivation
Mango	Alphonso, Pairi, Kallapady, Mundappa, Bangalore, Mulgoa, Neelum, Olour, Black Alphonso, Khudabad, Bennet Alphonso, Suvarnarekha, Fernandin, Mankurad	Are grown all over the region
Breadfruit	Seedless varieties	Is popular in the West Coast but is also grown to a lesser extent on the East Coast

Name of fruit	Varieties	Place of cultivation
Pineapple	Giant Kew Mauritius, Country or Indigenous types, Kew, Mauritius, Queen, Coorg Local	Are cultivated all over but common in West Coast
Cashew	Seedling trees	Grown all over uniformly
Citrus	1. MANDARIN (Loose jacket) (i) Kamla or Coorg Orange (ii) Kukul orange (iii) Seedlings 2. SATHGUDI (tight skinned orange) 3. LEMONS AND LIMES Italian, Nepali Oblong, Nepali Round, Eureka, Lisbon; seedlings of Kagzi nimbu	Mostly in Coorg and Wynad tracts in Madras Localised to Kukul Valley in the Nilgiris In Palni Hills and Kodaikanal areas Mostly confined to Malnad or hilly tracts of Kodur in Andhra Pradesh and Shimoga district of Mysore In Coorg, Nilgiris, Malnad or hilly tract in Andhra, north and south districts of Madras
Mangosteen	Seedling trees	Confined only to tropical ranges in the Nilgiris in Madras State
Banana	Poovan, Nendran, Mauritius, Ras-thali, Safed Velchi, Monthan, Chak-karakeli, Kunnan	Mostly cultivated in Madras, Kerala, Tanjore and Tiruchirapalli
Apple	Allsops Early, Singe Tellisch, Irish Peach, Carrington, Winterstein, and Rome Beauty	Grown mostly in the Nilgiris and Bangalore in Mysore
Pear	Keiffer, Jargaonells, Beure Glifford	-do-
Papaya	Round, Oblong and Honey Dew	Common all over this region

SECTION III

FARM ANIMALS, POULTRY AND FISH

CHAPTER 46

CATTLE

IT is impossible to think of improving agriculture in India without having good cattle. Holdings are small, agricultural practices are old-fashioned, and marketing of produce continues to be done with bullock carts. Cattle are, therefore, indispensable for the rural economy. They provide the required motive power for various agricultural operations including irrigation and rural transport, and also manure for the fields. Again, milk and milk products, which are the only source of animal proteins in the diet of the predominantly vegetarian population of the country, come from them. The farmer also supplements his meagre resources through the sale of milk and milk products, especially during the wide gaps that occur between the sowing and marketing of agricultural crops. Thus, development of cattle, both in regard to their milk yield and draught capacity, is very important for the country. At present, more than 50 per cent of our total agricultural income (Rs. 5,333 crores) is derived from cattle; and it is obvious that they should receive adequate attention in the planning programme for the rural sector.

Generally, good cattle are found in areas where fodder crops are grown in plenty. It is, therefore, necessary that a balanced agricultural policy should be evolved in which the cultivation of fodder crops finds an appropriate place in the crop rotation programme. Cultivation of leguminous fodder crops should be particularly encouraged as these not only provide a highly nutritious and inexpensive cattle feed but also supply very valuable green manure for the fields.

Indian breeds of cattle have a high reputation in foreign markets on account of their suitability for tropical countries by reason of their drought-resisting qualities and ability to withstand attacks by the major cattle plagues and tick-borne diseases. When the European colonists found that in the regions having hot, arid or humid climates and short growing seasons of pastures or long intermittent spells of droughts, the cattle introduced by them from temperate zones could not easily withstand either the climatic stress or the fluctuations in the feed

supply. They introduced zebu cattle from India for cross-breeding with a view to combining the productiveness of the European breeds with the hardiness and disease-resistant qualities of the Indian breeds. It was found that about 30 per cent of the Indian blood in cattle ensures the constitution necessary for withstanding the rigours of the tropical environment.

IMPROVEMENT OF STOCK

The bovine population of India is 203 millions, of which 158 million are cattle and 45 million buffaloes. This is a little over one-fourth of the world's total bovine population. The problem of planning developmental work for these large numbers is obviously a stupendous one.

Development of cattle can be taken up successfully only if we know the quality and potentialities of the stock available in the country. The Indian Council of Agricultural Research has been making a systematic study of the indigenous breeds, and the more important breeds of recognised cattle and buffaloes in the country have been defined. The Central and the various State Governments have established cattle breeding farms for the development of breeds in different parts of the country so that superior bulls may be available for stud purposes in their respective areas. Side by side, during the last 20 years or so, the Indian Council of Agricultural Research has established Herd Books for the registration of all the cattle which conform to breed characteristics, and come up to the prescribed minimum standard of production and pedigree. The minimum milk yield qualifications have been prescribed at 1,500 lb. for Kankrej, 2,000 lb. for Gir and Hariana, 2,500 lb. for Sittahi, and 3,000 lb. for Sahiwal and Murrah breeds, in a lactation not exceeding 300 days. Breeding and milk records are being maintained and cattle at Government farms and elsewhere registered. The records are being utilised for selection of stud bulls, and a programme of progeny testing is being gradually introduced.

CLASSIFICATION OF BREEDS

Broadly speaking, the Indian breeds of cattle can be classified under the following three heads.

Milch Breeds. The cows are high yielders; the bullocks are of moderate type or of poor draught quality. The animals are generally ponderous in build with pendulous dewlap and sheath, and having lateral and often curled horns. The Gir, Sittahi, Sahiwal and Tharparkar are some of the outstanding breeds of this group.

General Utility Breeds. The cows are fairly good milkers, and the bullocks are good for draught purposes. In this group, there are two types of cattle, viz.:

- (i) Short-horned, white or light grey cattle with long coffin-shaped skull and face, slightly convex in profile, e.g., Hariana, Ongole, Gaolao, Krishna Valley, etc.
- (ii) Lyre-horned, grey cattle, deep bodied with wide forehead, prominent orbital arches, flat or dished-in profile, and good draught capacity, e.g., Malvi and Kankrej.

Draught Breeds. The cows are poor milkers but the bullocks are excellent draught animals. In this group there are four types of cattle, viz.:

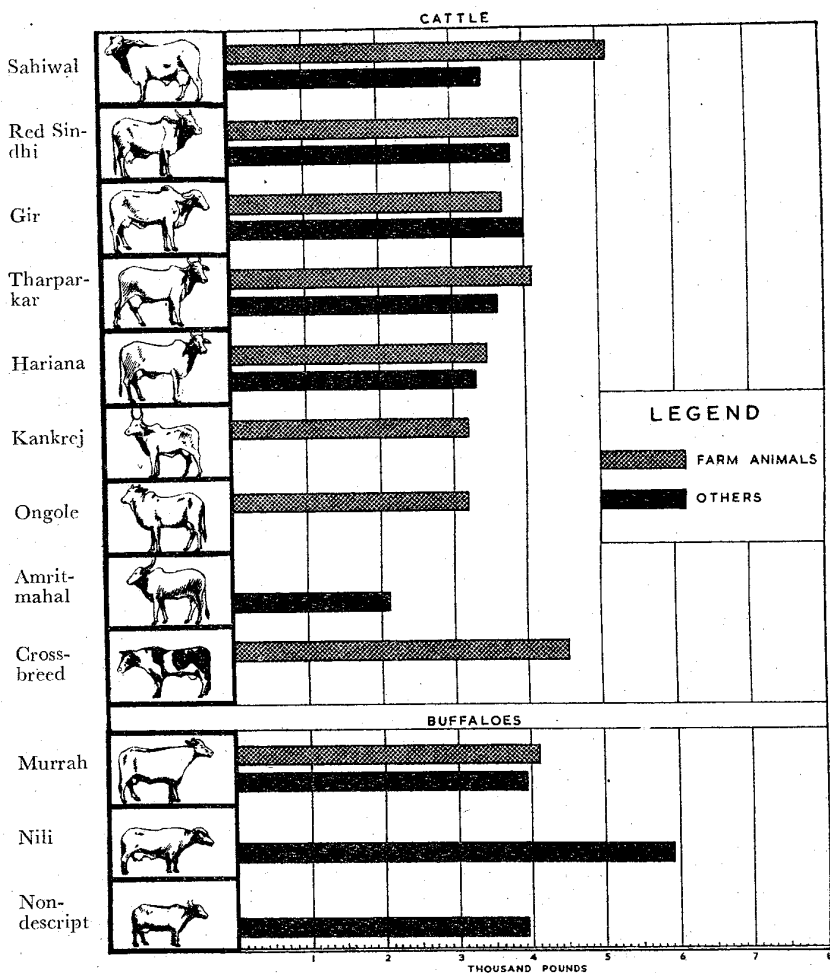


Fig. 43. Average milk yield of important breeds of cattle and buffaloes

(i) Short-horned white or light grey cattle with long coffin-shaped skull and face, slightly convex in profile, e.g., Nagori and ' Bachaur.

(ii) Lyre-horned grey cattle with wide forehead, prominent orbital arches, flat or dished-in profile, deep body and powerful draught capacity, e.g., Kenkatha, Malvi and Kherigarh.

(iii) 'Mysore type', characterised by prominent forehead with long and pointed horns which rise close together. The animals are, with a few exceptions, poor milkers, e.g., Hallikar, Amritmahal, Kangayam, Khillari, etc.

(iv) Small black, red or dun cattle, often with large patches of white markings, found in the rugged mountainous areas of the Himalayan region or at the foot of the hills. They have tight sheaths and are either short-horned or slightly lyre-horned. They are active, and are useful for light ploughing and miscellaneous work, but their milk yield is poor. They are able to thrive where large animals cannot survive. The Ponwar and Siri are notable breeds of the group.

There are also a number of indigenous breeds of buffaloes, e.g., Murrah, Mehsana, Surti, Nili, etc. Although the population of buffaloes is much smaller than that of cows, more than 50 per cent of the milk produced in India at present is buffalo's milk. On account of the higher fat percentage in buffalo's milk (average 7.5 per cent), it is more commonly used for the manufacture of dairy products, e.g., butter, ghee, cheese, khoa, etc., and it yields a much greater return than the cow's milk. Male buffaloes after castration are used for heavy transport as well as for ploughing. They are generally not worked during the hot parts of the day. Light coloured brownish breeds like the Bhadawari can, however, stand heat better than the jet black ones.

The chief characteristics of the important recognised Indian breeds of cattle and buffaloes by which they can be distinguished from one another, along with information about their habitat, breeding, forms, utility, body measurements and weights are given below:

CATTLE

(a) MILCH BREEDS

Breed	Habitat	Characteristic features	Utility
1. Sahiwal	Central and Southern dry areas of the Punjab (P); in the neighbourhood of Ravi and Nili Bar particularly Montgomery district; and in most large cities of the Punjab (1).	(a) Deep heavy body; short legs; fine loose skin. (b) Somewhat broad head; stumpy horns. (c) Usually reddish brown with or without white splashes. (d) Voluminous dewlap; pendulous sheath for which it is also called 'Lola'.	Good animals in villages yield 3,000 lb. milk in a lactation of 300 days. Well-bred herds in certain farms yield on an average 5,500 lb. Bullocks lethargic but useful for slow work.
Farms			
	1. N.D.R.I., Karnal.		
	2. I.A.R.I., New Delhi.	(e) Long whip-like tail almost reaching to ground; capacious udder.	
	3. G.D.F. Chak Ganjeria, Lucknow.		
	4. Agri. Col. Dairy, Kanpur.		
		Body Measurements	
		Male: Ht-53"; L-65"; G-76" Wt-1200 lb.	

Breed	Habitat	Characteristic features	Utility
	5. G.D.F., Telankhory, Nagpur.	Female: Ht-49"; L-56"; G-68"; Wt-900 lb.	
	6. C.B.F., Bhadri, Pratapgarh.		
	7. Satguru P.S.'s Farm, Bhaini, Sirsa, Hissar.		
2. Sindhi	.. Confined to western Sindh (W.P.) and also round about Karachi and Sindh.	(a) Medium sized; well proportioned; compact.	Milk yield in selected village animals about 2,500 lb. in a lactation of 300 days. Well-bred herds in certain pure bred animal with- farms yield on an average 4,000 lb.
	Farms	(b) Rather thick horns ending in a blunt point.	
	1. N.D.R.I., Karnal.	(c) Deep dark red colour, out large white patches.	
	2. Agri. Instt., Allahabad.		
	3. Govt. L.R.S. Hosur (Salem).	(d) Somewhat heavy hump, dewlap and sheath.	
	4. N.D.R.I., Sub-station, Bangalore.	(e) Capacious udder.	
	Body Measurements		
	5. P.L.B. Farm, Angul (Kissa).	Male: Ht-53"; L-58"; G-74"; Wt-925 lb.	
	6. Agri. Col. Dairy, Poona.	Female: Ht-46"; L-51"; G-75"; Wt-700 lb	
	7. Tisco Farm, Jamshedpur.		
	8. G.C.B.F., Gauhati.		
3. Gir	.. Originally Kathiawar, but has migrated to surrounding areas.	(a) Well proportioned body; robust constitution.	Cows good milker; certain village animals yield about 2,000 lb. in a lactation of 300 days. Well-bred herd in certain farms yield on an average 3,500 lb. Bulls heavy, powerful but medium paced, good for draught.
	Farms	(b) Prominent brownny forehead; curved horns turning backward at end.	
	1. G.C.B. & D.F., Jamnagar.	(c) Colour varies from shades of red and white to almost black and white or entirely red or white.	
	2. G.C.B. & D.F., Junagarh.		
	3. Ashram Gaushala, Sabarmati, Ahmedabad.	(d) Ears long and pendulous.	
	4. B.H.L. Gaushala, Kandivalli, Bombay.	(e) Tail long and whip-like with black switch reaching almost to ground.	
	5. Pinjrapole, Poona.		
	6. Pinjrapole, Sholapur.	(f) Prominent hip bones.	
	7. Pinjrapole, Nasik.	Body Measurements	
	8. Adarsh Dugdhalaya, Bombay.	Male: Ht-53"; L-60"; G-72"; Wt-1200 lb.	
		Female: Ht-50"; L-55"; G-66"; Wt-850 lb.	

Breed	Habitat	Characteristic features	Utility
4. Deoni ..	North-western and western areas of old Hyderabad State.	(a) Resembles Gir. (b) Less pronounced forehead. (c) Black and white or red and white with irregular patches and spots. (d) Well developed dewlap and sheath. (e) Ears pendulous but short without the notch near the tip.	Cows good milkers. Average yield is about 1,500 lb. in 300 days. Well-bred herd in farms, have average yield of up to 2,500 lb. Bullocks good for heavy work.
	Farm		
	1. Deoni C. B. F. Udgir (Bidal).		
		Body Measurements	
		Male: Ht-59"; L-66"; G-81"; Wt-1,300 lb.	
		Female: Ht-52"; L-56"; G-64"; Wt-750 lb.	

(b) GENERAL UTILITY BREEDS

5. Nimari ..	Namari district, Madhya Pradesh; Khargaon, old Indore State.	(a) Long body, straight back. (b) Medium sized head; somewhat bulging forehead. (c) Colour red with large white splashes. (d) Moderately developed dewlap and sheath, latter somewhat pendulous. (e) Long and thin tail with a black switch reaching almost to ground.	Cows poor milkers; individual yield 3-4 lb. per day. Bullocks docile and good at work.
	Farms		
	1. Gilligan C. B. F., Pimple (E. Khandesh).		
	2. C.B.F., Simrol, Indore.		
		Body Measurements	
		Male: Ht-61"; L-57"; G-68"; Wt-860 lb.	
		Female: Ht-52"; L-48"; G-63"; Wt-700 lb.	
6. Dangi ..	Akola taluk of Ahmednagar district, Sonkhad taluk of Khandesh district, Ghats of Nasik, Thana and Colaba districts and old States of Bausda, Dharampur Jawahar and Dangs.	(a) Medium sized body, oily skin. (b) Somewhat small head, projecting forehead, large muzzle, short and thick horns.	Cows poor milkers. Bullocks hardy; good for heavy rainfall areas.

Breed	Habitat	Characteristic features	Utility
		(c) Red and white or black and white.	
		(d) Ears small.	
	Farms	Body Measurements	
	1. G.C.B.F., Tegur, Dharwar.	Male: Ht-50"; L-53"; G-60"; Wt-800 lb.	
	2. G.C.B.F., Igatpuri, Nasik.	Female: Ht-46"; L-48"; G-57"; Wt-650 lb.	
7. Haryana	Rohtak, Hissar, Gurgaon and Karnal districts of the Punjab, Union Territory of Delhi, also exists more or less in pure form in old States of Jind, Nabha, Patiala, Jaipur, Jodhpur, Loharu, Alwar, Bharatpur and in western U.P.	(a) Body proportionate, moderately long, compact appearance. (b) Head is carried high; horns short, curving upwards and inwards. (c) Colour white or light grey. (d) Long and narrow face, black forehead, body prominent at the centre of the poll. (e) Comparatively small and sharp ears. (f) Small dewlap and sheath. (g) Well formed and compact udder. (h) Fine tail with a black switch reaching to half way between the hock and the ground.	Bullocks good workers particularly for fast ploughing and road transport. Cows good milkers with average lactation yield in selected village animals 2,500 lb. in 300 days; average production on certain farms 4,000 lb.
	Farms	Body Measurements	
	1. Govt. Livestock Farm, Hissar.		
	2. I.V.R.I., Izatnagar, U.P.		
	3. Dairy Demonstration Farm, Mathura.		
	4. M.S.F., Babugarh, Meerut.		
	5. M.S.F., Madhurikund, Mathura.		
	6. Cent. Livestock Res.-cum-Breeding Stn. Harin-ghata (W. Bengal).		
	7. Tisco Farm, Jamshedpur.		
	8. Satguru P.S's Farm, Bhaini, Sirsa, Hissar.	Male: Ht-56"; L-60"; G-76"; Wt-816 to 1076 lb.	
	9. Bhanti Gaushala, Kanpur.	Female: Ht-52"; L-54"; G-67"; Wt-584 lb.	
8. Mewati	Kosi tract of Mathura district and the old States of Alwar and Bharatpur.	(a) Similar to Haryana, evidence of Gir blood. (b) Bulging forehead; horns emerge from outward angles of the poll and inclined to turn backwards at the points. (c) Sheath pendulous but not over-developed.	Bullocks powerful, docile and good workers. Cows good milkers, yielding about 10 lb. a day.
	Farm		
	1. G.C.B.F., Alwar.		

Breed	Habitat	Characteristic features	Utility
Body Measurements			
		Male: Ht-59"; L-75"; G-82"; Wt-1350 lb.	
		Female: Ht-54"; L-58"; G-65"; Wt-800 lb.	
9. Rath	Northern and western areas of old Alwar State, in southern areas of old Rajputana. Outside this are found mixed with Nagor, Haryana and Mewati breeds.	(a) Basic characteristics similar to Haryana breed but smaller well built and deep chested. (b) Quarters well developed; tail carried higher than by most Indian breeds.	Bullocks powerful and active, suitable for medium field and road work. Cows yield about 10 lb. milk per day.
Body Measurements			
		Male: Ht-52"; L-58"; G-61"; Wt-700 lb.	
		Female: Ht-45"; L-49"; G-59"; Wt-500 lb.	
10. Ongole	Ongole tract of Andhra Pradesh, parts of Bapatla, Sathanapalli, Vinukonda and Kandukur taluks of Nellore and Guntur districts.	(a) Muscular and long limbs; large heavy body. (b) White colour; dark grey markings on head, neck and humps of males; black points on knee, pasterns of fore and hind legs. (c) Forehead broad between the eyes; horns stumpy.	Bullocks powerful, suitable for heavy ploughing or road work. Cows not so good for fast work. Good milkers having an average lactation yield of 1,500 lb. in 300 days, in selected village cattle; but in certain farms average in selected cows up to 3,500 lb.
Farm			
1. Govt. Livestock Research Station, Lam, Guntur.			
Body Measurements			
		Male: Ht-58"; L-66"; G-80"; Wt-1250 lb.	
		Female: Ht-54"; L-57"; G-71"; Wt-950 lb.	
11. Gaolao	Chindhwara, North Wardha and Nagpur districts of old Madhya Pradesh.	(a) Body medium sized; build light; dewlap voluminous; sheath moderately developed. (b) Head by long and narrow tapering towards muzzle, and somewhat broader at the base of horns. (c) Horns short and stumpy blunt at points sloping slightly backwards.	Bullocks good workers. Cows low yielders—average yield about 1,800 lb. in 250 days.
Farms			
1. G.C.B.F., Hethikundi, Wardha.			
2. Nalwadi Gaushala, Gopuri, Wardha.			

Breed	Habitat	Characteristic features	Utility
		(d) Ears medium sized.	
		(e) Tail comparatively short reaching a little below hocks.	
		Body Measurements	
		Male: Ht-53"; L-56"; G-68"; Wt-950 lb.	
		Female: Ht-48"; L-51"; G-62"; Wt-700 lb.	
2. Krishna Valley	Parts of Krishna River watershed, in southern areas of old Bombay and Hyderabad States.	(a) Body long and massive; chest deep and broad; neck short and powerful; limbs straight.	Bullocks very powerful, suitable for draught or heavy ploughing. Cows fair milkers average yield being about 2,000 lb. in certain farms.
	Farm	(b) Head comparatively small with a slightly bulging forehead.	
	1. G.C.B.F., Himayatsagar (Hyderabad).	(c) Horns small and curved usually emerging outwards and slightly curved upwards and inwards.	
		(d) Dewlap and sheath moderately developed.	
		Body Measurements	
		Male: Ht-56"; L-62"; G-80"; Wt-1,400 lb.	
		Female: Ht-49"; L-53"; G-62"; Wt-750 lb.	
13. Tharpar-kar	South-east Sind.	(a) Body medium sized, well proportioned and stockily built; limbs short and straight and strong; joints firm.	Cows good milkers; average lactation yield in selected village cows 2,500 lb. in 300 days. Well-bred herd in certain farms yield on an average 4,000 lb. medium sized.
	Farms	(b) Face moderately long with broad poll and slightly bulging forehead; horns medium sized.	
	1. N.D.R.I., Karnal, Punjab.	(c) Drooping and large ears, moderately developed dewlap and sheath.	
	2. G.C.F., Phulwari-Sharif, Patna.	(d) Somewhat drooping quarters; fine tail with black switch reaching to fetlocks.	

Breed	Habitat	Characteristic features	Utility
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- (e) Usually a white or grey line along spine particularly in young animals.

Body Measurements

Male: Ht-51"; L-60"; G-70"; Wt-1200 lb.

Female: Ht-48"; L-57"; G-66"; Wt-850 lb.

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|-------------|---|---|--|
| 14. Kankrej | South-east of the Rann of Kutch extending from south-west corner of Tharparkar district (Sindh) to Dholka (Ahmednagar) in south and from Dessa in east to extreme end of old Radhanpur State in the west. | (a) Heaviest of Indian Bullocks power-breeds; powerful body; broad chest; straight back; well developed hump; thick skin. | Bullocks power-breeds; powerful body; ful draught ani-mal. Cows fairly good milkers; average lactation yield in selected village animals 1,500 lb. in 300 days. Well-bred herds in certain farms yield on an average 3,500 lb. |
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Farms

1. Instt. of Agri., Anand, Kaira.

2. G.C.B.F., Kopargaon, Ahmednagar.

3. Cattle Farm, Chharodi, Ahmedabad.

- (c) Caronets of feet always black, black markings on hind and fore legs; marking in colour lighter in cows.

- (d) Dewlap moderately developed; sheath pendulous; tail of moderate length with black switch standing below the hocks.

- (e) Comparatively broad forehead slightly dished in the centre; strong curved horns covered with skin to a comparatively higher point.

Body Measurements

Male: Ht-54"; L-61"; G-75"; Wt-1,300 lb.

Female: Ht-52"; L-58"; G-71"; Wt-950 lb.

(c) DRAUGHT BREEDS

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|---------------|----------------------------------|--|---|
| 15. Nagore .. | North-east of old Jodhpur State. | (a) Body long, deep power-ful; straight back; moderately broad chest; strong and well developed quarters; short powerful neck; straight and muscular limbs with good feet. | Bullocks fast and good trotters. Cows in farms yield about 8 lb. of milk per day. |
|---------------|----------------------------------|--|---|

Farm

1. G.C.B.F., Nagore.

Breed	Habitat	Characteristic features	Utility
		(b) Face narrow and rather long; forehead flat, horns moderately developed emerging from outer angles of poll in outward direction and carried upwards with gentle curve to turn at points.	
		(c) Ears rather large, hump moderately developed.	
		(d) Skin fine, dewlap and sheath small; tail short with a black switch standing a little below hocks.	
		(e) Colour generally white or grey.	
		Body Measurements	
		Male: Ht-55"; L-62"; G-73"; Wt-1200 lb.	
		Female: Ht-54"; L-58"; G-65"; Wt-800 lb.	
5. Bachaur.	Bachaur Pargana, Darbhanga, Koilpur Pargana to Bhagalpur, Sitamarhi Sub-division of Muzaffarpur and Champaran district of Bihar.	(a) Body compact; back straight; barrel well rounded; neck short; shoulders muscular; forehead broad; eyes prominent and large; ears drooping.	Bullocks good for draught. Cows poor milkers.
	Farm	(b) Tail short.	
		(c) Colour grey.	
	1. G.C.B.F., Pusa, Darbhanga.	Body Measurements	
		Male: Ht-52"; L-59"; G-70"; Wt-750 lb.	
		Female: Ht-44"; L-47"; G-59"; Wt-500 lb.	
7. Kenkatha	Banda district (U.P.) also in some areas of Central India.	(a) Body short deep and compact; back straight; and feet good and hard; powerful. Cows sheath medium with black tip; dewlap medium sized; tail of medium length with black switch reaching below hocks.	Bullocks sturdy and fairly powerful. Cows poor milkers.
	Farm		
	1. M.S.F., Saidpur, Jhansi.	(b) Head short and broad; forehead dished; horns strong and pointed emerging from outer angles of poll in a	

Breed	Habitat	Characteristic features	Utility
		markedly forward direction, ending in a sharp point; ears pointed.	
		(c) Colour grey on barrel varying to dark grey rufous on the rest of body.	
		Body Measurements	
		Male: Ht-50"; L-47"; G-70"; Wt-760 lb.	
		Female: Ht-42"; L-45"; G-66"; Wt-650 lb.	
18. Malvi	Dry parts of Malva tract (Central India); also in a less developed form in northern areas of old Madhya Pradesh and north eastern area of old Hyderabad State.	(a) Body deep, short and compact; back straight; quarters drooping; sheath pendulous; dewlap moderately sized; chest broad; hump well developed.	Bullocks good for road and field work; economical feeders and can adapt to varying climatic and soil conditions. Cows fair milkers.
	Farms	(b) Head short and broad; forehead dished; muzzle marked broad and turned; horns strong and pointed emerging from outer angles of poll in a forward direction and terminating in sharp points; ears short and pointed; tail moderately long with black switch reaching to about fetlocks.	
	1. G.C.B.F., Simrol, Indore.		
	2. G.C.B.F., Agar, Shahjapur.		
	3. G.C.B.F., Dewal, Sagar.		
		(c) Colour grey, deepening in mature males to dark iron grey, almost black on neck shoulders and quarters.	
		Body Measurements	
		Male: Ht-50"; L-58"; G-78"; Wt-900 lb.	
		Female: Ht-41"; L-50"; G-57"; Wt-750 lb.	
19. Kherigarh	Territory between rivers Sarju and Mohan, north of Ghagra; poor specimens in Kherigarh Pargana of Lakhimpur Kheri district of U.P.	(a) Face narrow and small; horns thin and upstanding; eyes bright; ears small.	Bullocks good trotter and useful for light draught. Cows poor milkers.
		(b) Hump well developed in male; barrel well formed; sheath moderately	

Breed	Habitat	Characteristic features	Utility
		developed; sheath very small; skin tight, tail fine; moderately long ending in a black switch reaching little below hocks.	
		Body Measurements	
		Male: Ht-51"; L-57"; G-72"; Wt-1,100 lb.	
		Female: Ht-49"; L-51"; G-66"; Wt- 700 lb.	
22. Khillari	Sholapur and Satara district; Satpura range of old Bombay State; and southern Maharatta States.	(a) Derivative of Amrit-mahal but not so compact and active.	Bullocks very hardy, very suitable for fast road work. Cows poor milkers.
	Farms	(b) Body comparatively long and well arched; head massive; forehead slightly prominent; face narrow, horn long and sweeping, emerging close to each other at top of poll in upward direction.	
	1. G.C.B.F., Ranjani karan Ranjani, S. Satara.	(c) Hump well developed; dewlap voluminous; sheath small; tail comparatively short with a black switch reaching just below hocks.	
	2. G.C.B.F., Rai Baghmahal, Belgaum.	(d) Colour grey white.	
		Body Measurements	
		Male: Ht-54"; L-53"; G-78"; Wt-1,100 lb.	
		Female: Ht-49"; L-44"; G-66"; Wt-750 lb.	
23. Bargur	Bargur Hill forest in Bhavani taluk of Coimbatore district of Madras.	(a) Body smaller than Mysore type but more compact; forehead not so prominent; horns growing backwards and upwards; hump moderately sized; dewlap fine but well mashed; sheath fairly tight; tail rather short.	Bullocks stated to be unsurpassable in hardiness, spirit and speed, difficult to be trained. Cows poor milkers.
		(b) Colour usually red and white sometimes light grey.	
		Body Measurements	
		Male: Ht-46"; L-53"; G-68"; Wt-750 lb.	
		Female: Ht-43"; L-48"; G-65"; Wt-650 lb.	

Breed	Habitat	Characteristic features	Utility
14. Kangayam	Coimbatore district of Madras.	(a) Body moderately long; back straight; neck short and strong; dewlap small; sheath tight; skin fine.	Bullocks strong and good for draught. Cows poor milkers.
	Farms		
	1. Govt. Livestock Research Station, Hasur, Salem.	(b) Head moderately sized; forehead slightly prominent; muzzle fairly wide, tail fine, moderately long with a black switch reaching below hocks; horns strong curving upward and outward and slightly inwards from the top of poll; ears small and pointed.	
	2. C.B.F., Palaykottai, via Erode.		
		Body Measurements	
		Male: Ht-52"; L-60"; G-74"; Wt-1,150 lb.	
		Female: Ht-47"; L-53"; G-64"; Wt- 750 lb.	
25. Ponwar	Pilibhit and Kheri districts of U.P.	(a) Face narrow; neck short and powerful; barrel moderately long; sheath short and tight; hump well developed in bulls; tail long and tapering with a white switch; eyes big and bright; ears long and erect.	Bullocks remarkable for speed and stamina, good for field and road work. Cows poor milkers.
	Farm		
	1. M.S.F., Hempur, Nainital.	(b) Colour generally black and white.	
		Body Measurements	
		Male: Ht-50"; L-53"; G-63"; Wt-700 lb.	
		Female: Ht-45"; L-50"; G-62"; Wt-650 lb.	
26. Siri	Hilly tracts of Sikkim and Bhutan.	(a) Head small and square cut; forehead wide flat; horns sharp directed forward and upwards; ears small.	Selected cows' average yield 3,000 lb. in 280 days.
		(b) Hump placed well forward usually with a tuft of long, coarse hair at crown; legs and feet strong; dewlap moderately developed; sheath tight in males.	
		(b) Colour black and white or red and white.	

Breed	Habitat	Characteristic features	Utility
Body Measurements			
Male: Ht-54"; L-57"; G-73"; Wt-1,000 lb.			
Female: Ht-48"; L-51"; G-68"; Wt- 800 lb.			

BUFFALOES

1. Murrah	Rohtak, Karnal, Hissar, and Gurgaon districts of the Punjab, Delhi, also in western U.P. and old States of Jind, Nabha and Patiala.	(a) Body massive; neck and head comparatively light; horns short and tightly curved; udder well developed; hips broad; quarters drooping; tail long reaching fetlocks.	She buffaloes—most efficient milk and butter producers. Selected village animals yield 3,000 lb. in a lactation of 300 days. Well-bred herds in some farms yield on an average 5,000 lb.
Farms			
1. I.V.R.I.,	Izatnagar, U.P.	(b) Colour Jet black with white markings on tail, face and extremities.	
2. M.S.F.,	Babugarh, Meerut.		
3. M.S.F.	Madhuri-Kund, Mathura.	Body Measurements	
4. Tarai Dairy Farm,	Nagla, Nainital.	Male: Ht-56"; L-59"; G-88"; Wt-1,250 lb.	
5. Adarsh	Dugdhalaya, Bombay-8.	Female: Ht-52"; L-58"; G-87"; Wt- 950 lb.	
6. Tisco Farm,	Jamshedpur.		
7. Govt. Dairy Farm,	Val-tair, Visakhapatanam.		
2. Bhadawari	Originally from Bhadawari Estate in Agra district, Bah tehsil, and adjoining areas of old Gwalior State, also in Etawah district.	(a) Body medium sized and wedge shaped.	Average milk yield 8 lb. per day; fat percentage of milk very high. Males used for draught; can stand heat better than darker breeds.
Farm			
1. G.C.B.F.,	Bharari, Jhansi.	(b) Head comparatively small; bulging out between horns; leg short and stout; hooves black and higher than fore-quarters in female; tail long, thin and flexible with black and white or pure white switch reaching to hocks.	
		(c) Colour like copper; hair scanty and black at roots.	

Breed	Habitat	Characteristic features	Utility
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Body Measurements			
Male: Ht-51"; L-55"; G-74"; Wt-1,050 lb.			
Female: Ht-48"; L-54"; G-71"; Wt-850 lb.			

3. Jaffara-badi	Southern Kathiawar and in the neighbourhood of Jaffara-bad.	(a) Body longer but not so compact; dewlap and udder well developed; female somewhat loose; head and neck massive; forehead very prominent; horns heavy inclined to droop on each side of neck then turning up at points less tightly curved than in Murrah breed.	Males used for heavy draught. Females are very good milkers.
Farm			
1. G.C.B. & D. Farm, Morvi.			
(b) Colour usually black.			
Body Measurements			
Male: Ht-56"; L-66"; G-75"; Wt-1,300 lb.			
Female: Ht-55"; L-63"; G-74"; Wt-1,000 lb.			

4. Surti	Charottar tract of Gujarat and neighbouring area of old Baroda State, also in south Gujarat and Deccan, best specimens from Nadiad, Anand, Baroda taluk of Kaira district of Gujarat.	(a) Body well shaped, medium sized; wedge-shaped barrel. (b) Head long and broad rounded between horns; back straight; eyes prominent; horns sickle-shaped, moderately long and flat; tail fairly long ending in a white tuft.	She buffaloes economical milkers, average lactation yield of well-bred animals, on farms 3,500 lb. in 300 days.
Farm			
1. C.B.F., Bakrol, Baroda.			
(c) Colour black or brown; good specimens with two white collars—one round the jaw, the other at brisket.			
Body Measurements			
Male: Ht-51"; L-56"; G-73"; Wt-1,500 lb.			
Female: Ht-49"; L-54"; G-75"; Wt-1,300 lb.			

5. Mehsana	Mehsana district (old Baroda State) and the adjoining areas.	(a) Body longer than Murrah; limbs lighter, head longer and heavier.	Not a very pure breed but very good milkers and are popular for
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Breed	Habitat	Characteristic features	Utility
	Farm	(b) Horns usually less curled at the end as in Murrah breed but longer; udder well shaped.	city milk production.
	1. Govt. Agri. College-cum-Dairy Farm, Poona.	(c) Colour black for fawn grey with white markings on face legs or tail tip.	
		Body Measurements	
		Male: Ht-56"; L-70"; G-84"; Wt-1,250 lb.	
		Female: Ht-52"; L-61"; G-82"; Wt- 950 lb.	
6. Nagpuri	Nagpur, Wardha and Berar districts of old Madhya Pradesh; adjoining areas of old Hyderabad State, and also bred in Central and Southern India.	(a) Build generally higher than northern buffaloes; limbs lighter; tail comparatively short reaching a little below hocks; general appearance different from that of Murrah.	She buffaloes yield 12-16 lb. of milk per day. Males used for draught work; slow in movement.
	Farm	(b) Horns long, flat and curved, bending backward on each side of neck almost to shoulders.	
	1. G.C.B.F., Hetikundi, Wardha.	(c) Face long and thin, neck somewhat long.	
		(d) Colour usually black, sometimes white patches on face, legs and tail up.	
		Body Measurements	
		Male: Ht-56"; L-68"; G-83"; Wt-1,150 lb.	
		Female: Ht-52"; L-56"; G-81"; Wt- 900 lb.	
7. Nili	Sutlej Valley particularly Ferozepur district of the Punjab and parts of Montgomery district of West Pakistan.	(a) Head elongated, bulging at top, depressed between eyes; muzzle fine; frame medium sized.	She buffaloes high milkers; average lactation yields 3,500 lb. in a lactation of 250 days. Males used for heavy draught.
	Farm	(b) Horns small, coiled lightly; neck long thin and fine; navel very small; udder well developed.	
	1. Satguru Partap Singh's Farm, Bhaini, Sirsa, Hissar.	(c) Tail long, almost touching ground.	

Breed	Habitat	Characteristic features	Utility
		(d) Colour usually black with white markings on forehead, face, muzzle and legs.	
		Body Measurements	
		Male: Ht-54"; L-62"; G-89"; Wt-1,300 lb.	
		Female: Ht-53"; L-58"; G-88"; Wt-1,000 lb.	

Abbreviations. LV.R.I. : Indian Veterinary Research Institute; N.D.R.I. National Dairy Research Institute; LA.R.I. : Indian Agricultural Research Institute; G.C.B.F.: Government Cattle Breeding Farm; G.D.F. : Govt. Dairy Farm; G.C.B. & D.F. : Govt. Cattle Breeding and Dairy Farm; M.S.F. : Mechanised State Farm; L.R.S. : Livestock Research Station; P.L.B.F. : Provincial Livestock Breeding Farm; C.B.F. : Cattle Breeding Farm; B.H.L. : Bombay Humanitarian League; P. : Pakistan; I. : India.

Ht: Height at withers; L: Length from shoulder point to pin bone; G: Heart girth; Wt: Average body weight (Adults).

BREEDING POLICY

An all-India cattle breeding policy has been laid down by a joint Committee consisting of members of the Animal Breeding Committee and the Livestock Committee of the Indian Council of Agricultural Research which has been accepted by the Central and the State Governments and is now adopted throughout the country. According to this policy, each State has been divided into zones, and allocation made regarding the breeds of bulls suited for each zone. Generally speaking, it is intended to develop the well defined local breeds by selective breeding in their native tracts, and to take up upgrading of the indigenous stock in other areas with the help of suitable Indian breeds, preferably general utility or milch breeds. The only exception is the hilly and heavy rainfall areas where

cross-breeding with bulls of imported dairy breed's like the jersey is being tried. As regards the draught breeds, which predominate in the country, the policy has been to develop their milch qualities to the maximum possible extent through selective breeding without causing any deterioration in their draught capacity. However, since much progress has not been made in this respect, their crossing with a suitable general utility breed like the Haryana, Ongole, Kankrej, etc., or a W filch breed like the Gir, Tharparkar, etc. is now being considered so that their milk yields may be increased expeditiously without upsetting their draught qualities. In the case of milch and general utility breeds, selective breeding is being rigidly followed to obtain maximum development of their potentialities for milk production.

CHAPTER 47

SHEEP

INDIA was once a vast pastoral country, where domestic animals constituted a man's entire wealth and answered most of his needs. Rearing of sheep then formed, as it does in some parts even now, one of the principal occupations of the people. But with increasing human population, grazing lands were progressively brought under the plough, and rearing of livestock generally declined in importance. Maintenance of cattle and sheep as a source of livelihood became a distinct occupation in course of time, and was left to special communities who moved with their herds from place to place grazing the animals wherever they found good pastures. With the extension of agriculture, these nomadic tribes began to disappear, and raising of cattle eventually became a part of agriculture.

Sheep rearing, however, still remains the monopoly of a class of herders whom tradition has marked out as a pastoral caste. The social, economic and political changes that have taken place have not touched this class, and the shepherd still follows his profession in the same manner as his ancestors did for centuries. To him the rearing of sheep is not only a profession but also a way of life that he loves. In harmony with nature, he and his flocks live in close friendship, oblivious of the vagaries of weather. During the rains, his sojourn is the desert or the arid hills where the flocks can graze on dry healthy lands free from humid and pest-infested lush grasses. His home, a mud or thatched hut, is located in some dry area, where he migrates during the monsoon to escape heavy rains. Shepherds who move to the Himalayan mountains generally have their homes in the plains or in the lower altitudes where they return during the winter season. Home-coming is the occasion for renewing family contacts and for attending to household matters.

After the rainy season the shepherds move to the harvested fields. This often involves long treks. But they get a warm welcome from the cultivators for the flocks, wherever they are folded, provide rich manure to the fields.

The unit of count for flocks is usually a Kaudi or Beesa- a group of 20 sheep-for a score is a convenient reckoner. A larger flock is expressed in multiples of 20, any excess number being mentioned as an addition to the Kaudis or Beesas. Three Kaudis of sheep are considered a normal possession which suffices for the maintenance of an average family; a flock of eight to ten scores is a rich possession; and those owning twenty Kaudis are sheep kings.

There are 39 million sheep and over 54 million goats in the country. It is the usual practice with shepherds to keep mixed flocks of sheep and goats.

The average fleece weight is estimated at 12 lb. per sheep per year, and the total annual clip of the country is in the neighbourhood of 68 million pounds. The major portion consists of coarse, hairy and coloured woofs.

Wool is an important item of export, and fetches about Rs. 120 million annually from foreign markets, particularly from the U.S.A. and the U.K. The annual yield of mutton is estimated at 900 million pounds. Income from skins and pelts is about Rs. 178 million.

The yields from sheep are, however, poor and do not suffice for the requirements of the country. Large quantities of fine wool, estimated at Rs. 110 million annually, are imported for the manufacture of finer types of fabrics. Meat production is also low. Excepting a few areas, nowhere in the country sheep breeding is considered a profession of status. There is, however, great scope for development, and if public interest can be secured, the industry would make considerable progress. In spite of the existence of a large number of non-descript sheep in India there are outstanding hardy breeds which can easily provide basis for improving the stock.

BREEDS

There exists no scientific classification of Indian breeds. If asked to state the breed of his sheep, the shepherd cannot say anything more than calling them either desi or by some local name. The names of breeds which appear in the literature on the

subject are coined by the authors after the locality in which the animals are generally found.

Broadly, there are three types of sheep in India, and these correspond to the three geophysiographic divisions of the country, viz., the Himalayan region, the Indo-Gangetic plains, and the Deccan Plateau. A brief account of the principal breeds found in these regions is given below.

Himalayan Region. The Himalayan region, particularly the western zone, comprising the hill regions of Uttar Pradesh, the Punjab and Kashmir, is an important sheep-rearing area. The steep gorgeous hills, towering over the plains in a series of earth-folds, afford grazing facilities for the flocks at different heights during the year. The grasslands situated at altitudes ranging from 9,000 to 12,000 feet are a unique bounty for the flock-owners, migrating to this region in summer. The frozen rugged plateaus of the accessible Himalayan peaks after winter, transform themselves into rich pastures. These grasslands are situated at heights where the heavy clouds which cause rain in the lower valleys do not reach-. Rainfall is in the form of fine intermittent spray which does not affect the health of the flocks or cause particular hardship to the shepherds. Before the commencement of winter the flocks move down into the valleys or to the nearest cultivated plains. The journey to the hills and back to the winter resort ranges from 150 to 200 miles. The sheep in this region have adapted themselves to the stresses involved.

The Himalayan sheep originate from the flocks reared in the high plateaus bordering Tibet, and from the breeds of the plains. The sheep which graze on the lower altitudes during winter and do not migrate to higher elevations have coarse fleece. The fine downy wool which forms the undercoat of the hill sheep is larger in the case of breeds maintained in drier and colder regions. The sheep of the eastern hill districts carry hairy wool on account of higher precipitation and humidity. The Chamba, Kulu and Kashmir Valley sheep have superior fleece, although there is considerable admixture of hairy and coloured fibres.

Gurez. A shepherd of Kashmir considers that the best sheep for wool production are raised in Gurez tehsil which is situated in the high elevated zone of that State. The flocks are

raised on rich summer pastures, and stall-fed during winter on stored grasses and fodders. The Gurez sheep is the biggest among the Kashmir breeds, the wool is less hairy, and the yield ranges from 2 to 3 lb. per half-yearly clip. The majority of sheep are hornless. Their ears are short, and the wool is predominantly white. A number of coloured sheep' are also maintained for getting woofs of natural shades of grey, black and brown.

Karnah. The tehsil of Karnah with an elevation ranging from 4,000 to 15,000 feet has a separate breed. The best specimens of this breed are found near Kel which has a summer ranch with excellent natural grasses. Rearing methods are the same as are followed in the Gurez area. The ram has big curved horns, long face, and a prominent nose. It is said that the black-faced Persian sheep was once introduced into this area; and the flocks now reared appear to have inherited some of the characteristics of the original exotic breed-particularly in regard to the quality of wool, which is medium short. The wool is utilized locally for the manufacture of woollen goods. -

Bhakarwal. At the foot-hills of the Kashmir region of the Himalayas a shepherd class known as ' Bhakarwal' rears sheep which have adapted themselves to the warmer region of the Jammu province as well as to the high. ranges of the Pir Panchal mountains. A number of flocks also migrate to Kashmir Valley, Liddar, and Pahalgam. The woofs are generally found mixed with coarser staple. Clipping is done thrice yearly. The rams are horned but the ewes hornless. The ears are generally long, broad and drooping. It is said that the fat-tailed sheep of the frontier region were once introduced into this area, and that the present-day sheep have inherited their larger frame from them.

Bhadarwah (Gaddi). The Kister and Bhadarwah tehsils in the Jammu province have an important breed' called Bhadarwah ' or ` Gaddi. ' These sheep live on scrub forest during winter, and migrate to Paddar and other neighbouring ranges. A large number of Gaddi sheep are also raised in the Kulu and Kangra Valleys. These are small in-size but are sturdy climbers. The rams are horned, and the ewes hornless. The fleece is generally white with brown coloured hair on the face. The wool in good sheep is lustrous, and the undercoat is used for the manufacture of high quality Kulu shawls and blankets.

Rampur-Bushair. One of the outstanding breeds of the Himalayan region - is the Rampur-Bushair sheep of Himachal Pradesh. The flocks migrate to the border of Tibet in summer and return to the lower Shiwalik ranges in the Jamuna, Tons and Suttlej Valleys. Considerable variation is met with among the animals of this breed, and consequently there is no uniformity in stature or wool-yield. Selected sheep have superior fleeces of medium quality, and the yield ranges from three to four lb. A large number of brown-coloured flocks are also reared for the production of tweeds. These sheep are also used as pack animals along with goats for trade with the Tibetan borders.

Sikkim. In the eastern heavy rainfall zone of the Himalayas a big sturdy black-faced sheep is raised at high altitudes. The breed has descended from the wild large-horned sheep that have a typical heavy black face, a prominent nose, and white body. The wool is coarse and the meat is of the quality of wild game. These sheep are reared chiefly for the meat requirements of the hill tribes inhabiting the cold wet forests.

In this region there is another type of sheep which is generally hornless and has a straight brown-coloured face and a low-set long body. Both the black-faced and the brown-faced types are reared in Nepal, Sikkim and parts of Assam.

Dry Northern Plains. The sheep of north Indian plains are good producers of carpet wool which forms the bulk of the exported clip. The flocks in Rajasthan, parts of Madhya Pradesh and north Gujarat are adapted to the dry intense heat and severe cold of these areas. They subsist on meagre grazing, and can stand long treks and recurrent droughts. Outstanding breeds which have adapted themselves to the desert conditions are described below.

Lohi. The long-eared Lohi is a proud, sheep. There is no other breed- in the world which has such long ears and graceful upright carriage. The brown heads with 'Roman noses' and long leathery ears are held above the back-line when the flocks march back from the grazing lands. Lohi is essentially a farmers' animal, highly suited to a mixed farming economy. High meat yield is its speciality, while production of coarse wool is the defect. The ewes have a good flow of milk and raise big twin lambs. Outstanding flocks of the breed are now in Pakistan but a sub-class is reared in the southern districts of Rajasthan, where

it is known by different names such as Malpuri, Sonadi, Chamthri, etc.

Bikaneri. The brown-headed Bikaneri sheep is an aristocrat among the sheep of Rajasthan. The wool yield, ranging from 4 to 9 lb., is the highest compared to the yields obtained from other breeds in India. The Magra, Chokla and Nali are the three types that have adapted themselves to the different soil and climatic conditions of the Bikaner area. The Cholsla type is a small sheep yielding finer wool. The word 'Magra' denotes 'land of pebbles', and the flocks of this class are known for their capacity to walk long distances over hard ground. The animals are bigger, have long legs, and can stand severe drought conditions. 'Nali' indicates low-lying lands, where a coarse-wooled big-framed breed has been evolved. These sheep have an admixture of the Lohi breed. Many a flock flaunts long ears and brown faces. But the majority of sheep in the Magra and Nali areas have small tubular ears with brown patches of hair on the face.

Marwari. In the Jodhpur division of Rajasthan State, exists a hardy black-faced breed yielding white wool of a mixed hairy composition. It is called Marwari. Outstanding flocks are raised in Pali and Barmer districts. The animals migrate to distant places in Uttar Pradesh, remote districts of Madhya Pradesh, and sometimes to the northern zone of Maharashtra. The wool yield is from two to four lb. and is of the coarser carpet variety.

Kutchi. The desert of Kutch and the sandy districts of north Gujarat possess a dark chocolate-faced sheep which can be regarded as the best dual-purpose breed in the country. It has a well-proportioned stocky frame covered with fine carpet wool. It also supplies milk when grazing conditions are satisfactory. The breed has a great future, for it is a high yielder of good wool, meat and milk.

Deccan Plateau. Peninsular India has a greater concentration of sheep population than the northern plains. Basically, there are two types of sheep in this zone; one which is raised for wool, and the other meant solely for meat production. These are described below.

Deccani. This breed is found in the Bombay-Deccan region and parts of Mysore State. It is an admixture of the Rajasthan breeds and the entirely hairy sheep of the eastern

portion of the plateau. The animals are small and hardy, and well adapted to poor pastoral conditions. The woofs are of black and grey colours; the fibre-composition is a mixture of hair and fine wool. The yield per head is about one pound annually. The flocks are maintained chiefly for meat production and for fertilizing the lands. In spite of the mixed coarse wool now obtained from these sheep, breeding of superior types is possible and should be attempted, for the animals have a fine undercoat. By using white-fleeced rams for breeding, the coloured strains in the wool can be eliminated.

Nellore. The Nellore breed of South India has many well marked characteristics. It is considered the tallest breed of sheep in India. The coarse hairy growth breaks away as the animal grows, and only a static coat is maintained. Traces of fine undercoat appear during winter, but these also disappear. The rams are horned, and the ewes are polled. The male wears an adornment of stiff long hair on the dewlap and brisket; in ewes there is no hair under the neck. Two long fleshy tassels grow under the neck. The tail is very short with a hair whorl at the end. The majority of the flocks are of fawn or deep red fawn colour. In certain areas white sheep with black spots on the face are considered a special variety. Where sheep are raised by the farmers, short-legged blocky types are evolved. Of these the Bannur variety is an outstanding sheep of Mysore. In areas which are adjacent to the wool-yielding flocks, this hairy breed has given rise to admixtures which are confused as separate breeds.

CHAPTER 48

GOATS

THE goat is the major supplier of meat in India. In addition, it yields milk and is a valuable source of leather. The rearing of goats, as compared to that of other livestock, is cheap. The owner spends little on it save his own labour; and for that reason it is followed extensively as an occupation by a large section of landless labour in the countryside.

The animal has adapted itself to the natural conditions obtaining in all regions of the country. In certain areas milch types have been developed but the majority of the herds are raised mainly for the meat market. Kidding twice in fourteen months is common as also the birth of twins or triplets. This high fertility guarantees an assured income to the rearer. The male kids are sold at the age of five months while the females are generally retained for replacement.

There are over 56 million goats in the country, yielding about 160,000 tons of meat annually. The skins and hair also constitute important products. The annual production of these is of the order of 22 million skins valued at Rs. 69 million, and 7 million lb. of hair valued at Rs. 7.2 million. Large herds of goats are generally owned by the nomadic shepherds who live in the arid areas during the rainy season and move to the fields after the harvest of crops. A considerable population of goats is also maintained by individual families, particularly those who do not own land. Milk from goats is a great asset to those who cannot own a cow or a buffalo.

On account of its habit of nibbling the buds of trees, and of foraging on a variety of plants, the goat is considered a destroyer of vegetation. The animal is, however, not to be blamed, for it is the keeper who is to be held responsible for such a loss. Owing to his poverty he generally lets his flocks wander about in search of food. If the country has to develop its forestry and garden lands, the present method of goat rearing will have to be restricted. Eliminating goat from the rural economy is hardly a desirable solution of the problem, for it is a highly useful animal deserving attention.

BREEDS

The majority of goats in the country are non-descript; but outstanding breeds are reared in certain areas. The following is a brief description of the principal breeds which have given rise to a number of sub-types or local breeds.

Himalayan Goat. The white-haired Himalayan goat, raised in the western zone comprising the States of Himachal Pradesh, the Punjab and Kashmir, is a beast of burden and a meat producer. Sturdy bucks are castrated and retained by the traders or shepherds, who migrate to the Borders of Tibet. Each animal transports about 14 lb. of merchandise. thousands of these trek through the valleys and march on to the highlands and back. The hair obtained from these goats is also a source of income. the breed receives different names after specific localities, such as, the Chamba, Gaddi and Kashmiri. The diminutive Pashmina goat is a unique type raised at elevations above 11,000 feet in the Himalayas and on the Tibetan plateau. It produces the softest and the warmest animal-fibre used for high quality fabrics made in the Kashmir and Kulu Valleys. The fine undercoat of the goat is combed out of the hairy fleece after winter. The yield of this valuable downy hair varies from 3/4 to 2 oz. per goat. The coarse hair from the outer coat gets mixed with the fine fibre, and the rough staple has to be picked by hand before the prized fabrics can be Prepared.

Off-shoots of the Himalayan goat, with admixtures of other breeds, are reared in the arid regions of the northern plains. Those that are bred to a uniform colour and stature are the black-haired Marwari and Mehsana breeds.

Jamunapari Goat. The Jamunapari is the biggest and the most majestic breed of goats in India. Its home lies between the Jamuna, Ganges, and Chambal rivers. It is a dual purpose goat, combining meat and milk qualities, and is an important source of income in many a household in the rural and urban areas. The breed has no uniform colour, but animals having a white coat with tan markings are considered the right type. Like the Lohi breed of sheep, these goats have long pendulous ears which are often ten to twelve inches in length. Selected bucks

are 50 inches tall _ and nannies stand 40 inches in height; the former weigh 150 to 200 pounds, and the latter 100 to 140 pounds each. Nannies raised for milk production yield 800 to 1,200 lb. of milk per lactation, with a fat content of 3~5 per cent. Whenever a large-sized goat is desired, this breed is used for evolving new varieties. One of the outstanding types thus bred is the Beetal goat in the Punjab.

Barbara Goat. The small short-haired and erect-horned Barbari goat is popular in the urban areas of Delhi, Gurgaon and Karnal districts. The breed has originated from the dwarf varieties of the central and west Africa. Its colour is generally white with red or tan spots. Considering the relatively small size of the nannies, this breed can be reported as a good milch type. It can be stall-fed and can live in confined conditions in cities, yielding two to three pounds of milk a day.

Surti Goat. The white small-legged Surti goat is popular in all the towns of Gujarat .It is .said that this breed has originated from Arabia. It is more or less of the same type as the Barbari, and is a good milk producer. It is maintained in many towns and is named after the locality.

Bengal Goat. The bantam Bengal goat has adapted itself to the meagre feeding conditions and heavy rainfall of the eastern region. Its legs are short, but the body is deep and the meat is considered excellent. The weight of the buck varies from 30 to 34 lb., and of the nanny from 20 to 30 lb. Twinning is common, and the nannies kid almost twice in a year. The skin is of a superior quality and is in demand both in India and abroad. Except for nourishing the kids for a brief period, the nannies do not yield any appreciable quantity of milk.

CHAPTER 49

POULTRY

THE term poultry refers to domestic fowls which are reared for their flesh, eggs, or feathers, and includes barndoor fowls or chickens, ducks, geese, turkeys, guinea-fowls, pigeons, pea-fowls, etc. However, the most important member of the family is the barndoor fowl or chicken with which we are concerned in this chapter.

In the East, poultry keeping dates back to very early times. In fact, India and the neighbouring countries are considered to be the original home of the jungle fowl from which the domestic birds have descended. The Chinese Emperor Fu-Hsi, who lived from 3341 B.C. to 3227 B.C. taught his people to breed fowls. Similar references to poultry breeding in India are also found in ancient history. The Aseel, a noted Indian breed, was highly prized by lovers of cock-fighting all over the world. However, systematic rearing of birds for marketing was not common, and even nowadays the poultry industry in the country is a disorganized enterprise. The birds are raised mostly in the villages where they are maintained in small units without any care being taken about their feeding, housing, breeding, diseases or marketing. Degeneration of stock, slow rate of growth, low production and heavy mortality are, therefore, the natural consequences. However, a number of schemes are now in operation which are expected to bring about speedy improvement, particularly in the breeding and management practices.

According to 1956 Census, the total poultry population (including ducks) in India is about 97 million, or about ten per cent of the world figure. About 36 million birds are hens, producing nearly 1,908 million eggs annually, valued at about Rs. 15.2 crores. The value of table birds has not been estimated, but it is not less than that of the eggs. The yield of feathers and poultry manure is also substantial. The importance of poultry husbandry in the economy of the country can therefore be easily imagined. However, the laying capacity of the birds is very low.

Compared to the world average -of 120 eggs per hen per annum, the production in India is only 53.

BREEDS

Domestic fowls in India may be divided into two broad groups: the desi or the indigenous, and the improved or exotic. The term desi encompasses all indigenous fowls which are not of any pure breed. They have generally local names such as Tenis, Naked-neck, Chittagong, Punjab Brown, Ghagus, Lolab, Titre, Busra, Karaknath, Denki, Tellicherry, Kalahasti, etc.

The imported (exotic) breeds which have been acclimatised in India are mostly the White Leghorn and Rhode Island Red. Some other breeds, such as Black Minorca, Plymouth Rock, Australorp, New Hampshire, Light Sussex, Brown Leghorn, etc., have also been introduced on small scale. The number of pure-bred birds of imported (exotic) varieties is only about 1.4 per cent of the total poultry population in the country.

There are several classes of fowls in India; within Each class are many breeds with different varieties and each variety has strains. Sometimes the birds are classified as egg, meat and general 'or dual-purpose types. This classification is known as 'utility classification'.

The standard or 'official' classification distinguishes various groups of birds, largely on the basis of geographical regions where they were originally developed. The most important classes are: (i) American, (ii) English and (iii) Mediterranean. These are described below.

American Class. All American breeds can be classed as general or dual-purpose breeds, and are valued for both eggs and meat. They are generally more popular than other types. 'The most important breeds of the American class are Rhode Island Red, Plymouth rock and New Hampshire.

Rhode Island Red. It is one of the best all-round breeds. The birds have long rectangular body, which is also broad and deep. The quality and yield of meat are good, and the egg-laying capacity is excellent; the hens laying large brown-shelled eggs.

The plumage colour is a rich dark or brownish red, evenly distributed over the entire surface, and is well glossed. The wing

when open shows black in both primaries and secondaries. The tail coverts, sickle feathers, and main tail feathers are also black. The prevailing colour is, no doubt, brownish red, but buff, white and brown colours are also common. There are two varieties, the single-comb and the rose-comb, which are otherwise identical. The single-comb variety is the more popular of the two. The lobes are red and so are the eyes. The legs and feet are generally deep yellow or reddish, horn and the beak reddish.

The Rhode Island Red is admittedly one of the hardiest of all breeds. The chickens grow quickly, are easy to rear, and no weather seems too severe for them. They stand cold and dampness very well and are, therefore, well suited for the wet, heavy rainfall regions. The standard weights, in pounds, are: cock 8 1/2 ; hen 6 2 ; cockerel 7 1/2 ; pullet 5 1/2.

Plymouth Rock. It is one of the most popular breeds in the West, especially in the U.S.A. The bird is of good size, with excellent fleshing properties and good egg-laying capacity. It has a single comb. The standard weights in pounds, are: cock 9 1/2 ; hen 7 1/2 ; cockerel 8 ; pullet 6.

The plumage colour of the Barred Plymouth Rock is greyish white, With each feather crossed by almost straight black bars, extending down to the skin.

In the males, the black and white bars should be of equal width, Whereas in the females the black bars may be one-and-a-half times as wide as the white ones. Breeding from birds which have very narrow barring, results frequently in slow growth, poor feathering in early life, and defects in the wings and tails of adult birds. Barred Plymouth Rock cocks, like the Rhode Island Red males, are good for upgrading the ordinary village or desi fowls.

New Hampshire. It is a relatively new breed of the American class developed in New Hampshire from Rhode Island Red stock. The shape of the body is less rectangular than that of the Rhode Island Red. Because of its unusual hardiness, it has rapidly gained in popularity.

The colour of plumage is chestnut red, but is not so well established as in the Rhode Island Red. The comb is invariably single. The hens lay large brown-shelled eggs. The standard weights in pounds are: cock 8 1/2 ; hen 6 ; cockerel 7 1/2 ; pullet 5 1/2.

English Class. The English breeds are mostly of utility type, noted for their excellent fleshing properties. Excepting the Cornish, all the breeds have white skin and red ear-lobes, and excluding Dorking and the Red Cap, all of them lay brown-shelled eggs. All are broody. .

There are six breeds in this group, of which the Sussex, the Orping-ton, and the Australorp are the more important.

Sussex. The bird has a long body, broad at the shoulders and of good depth from front to rear. The breast is, prominent and well developed, and the bird has excellent fleshing qualities. Single comb and horned coloured beak, shanks, and toes are other characteristic features. Three varieties of the type are known, of which the Light Sussex is the most popular. The standard weights in pounds; are: cock 9; hen 7; cockerel 7 1/2; pullet 6..

Orpington The bird has a body of characteristic size and shape-long, deep, low-set, heavy-boned, and well rounded, with a full breast and a broad back. It is a little more loosely feathered than. the breeds of the American class. The comb is single. The type is generally good for table purposes, but some fine laying strains have also been developed, by selective breeding and management. The Buff variety is the most popular. The standard weights in pounds, are: cock 10; hen 8; cockerel 8 1/2; pullet 7.

Australorp. This type was developed in Australia from the Black Orpington. The bird is more upright, and less massive in appearance than the Orpington, and has been developed as an egg producer. It has also plenty of flesh which makes it a good dual purpose fowl. The back is somewhat long, and the body slopes gradually towards the tail. The body is of good depth; the feathering is more closely fitting than in the Orpington. The comb is single, the beak is black, and the shanks and toes are black with the bottoms of the feet and toes pinkish white. The plumage colour is lustrous greenish-black and the under colour is dull black.

The Australorp is rapidly gaining in popularity in India. Like the Rhode Island Red, it is well suited for back-yard poultry farming, particularly in the wet and heavy rainfall regions. In recent years the ` Austro-White ', which is a hybrid between the Australorp male and the White Leghorn female, has attracted a good deal of notice. It is an excellent layer with good vigour and

large flocks of it are maintained on commercial egg farms. The standard weights of the bird in pounds, are: cock 8 1/2; hen 6 1/2; cockerel 7 1/2 ; pullet 5 1/2.

Mediterranean Class. All the Mediterranean breeds have non-feathered shanks and white or creamy-white ear-lobes. With the exception of Minorcas, fowls of this class are small in size. They mature early, are good foragers, possess a nervous, active temperament, and are non-sitters. They require less feed for maintenance and production than breeds of the other two classes described above. They are very good layers, and their eggs are white-shelled. Among them, the Leghorn is the most popular variety, with Minorca being next in importance:

Leghorn. This bird is small, active and reputed for the graceful blending of its various parts. Common varieties of Leghorns are the White, Brown, Black and Buff. The White variety has particularly gained popularity all over the world. Next in importance are the Brown and the Black varieties.

The White Leghorn is an excellent layer, but is not favoured much for table purposes. In India, it has gained wide popularity, especially in the drier regions. However, on heavy soils, and in wet areas, it has not been found to thrive and produce well.

Minorca. The bird is noted for its length of body, large comb, and long wattles. In fact it is the largest of the Mediterranean breeds.

There are Black, White and Buff varieties, the most popular, however, being 'the single-comb Black Minorca, which has an attractive metallic black plumage and an unusually large comb. As in the Leghorn, the comb is erect but has six evenly and deeply serrated points. The blade of the comb has a tendency to follow the neck. In the female also the comb is large and six-pointed, the front folding to one side and the rest is black; the shanks and toes are black or dark slate.

The breed was at one time even more popular than the Leghorn because of the superior size of its white eggs. It is, however, going out of favour now, probably because of the decline in production. The standard weights, in pounds, are: cock 8; hen 6 1/2; cockerel 6 1/2; pullet 5 1/2.

POULTRY DEVELOPMENT

Among the first attempts made to popularize scientific poultry keeping in the country, those of the foreign Christian Missionaries who had introduced small flocks of improved breeds from their own countries are to be reckoned as the most important. The superior performance of these breeds as compared to that of the desi varieties attracted notice, particularly of Government. Model poultry farms were set up, and arrangements were made for providing training in poultry keeping as well as for supplying purebred stocks to the people.

Later, on the recommendations of the Royal Commission of Agriculture, a poultry research section was established at the Indian Veterinary Research Institute at Izatnagar. This was, indeed, a landmark in the development of poultry husbandry in the country. The institute undertook fundamental research on problems relating to poultry keeping, and also initiated training schemes.

This was soon followed by many of the States setting up their own research and extension organizations. Further impetus to the development work came during World War II when the demand from the armed forces caused special attention to be given to the industry. Several large farms with improved breeds were speedily established. These farms eventually contributed to the raising of nucleus stocks of improved birds.

The Grow More Food Campaign started during the war, proved to be of special benefit to the industry. A number of poultry development and research schemes were sponsored under it by the Indian Council of Agricultural Research in several States. These brought about extensive improvements, especially in the field of disease control. Vaccines were evolved to check diseases like Ranikhet and fowl pox, against which the poultry keepers had no protection previously, and which had made poultry husbandry a highly risky enterprise. These vaccines were popularised on a country-wide scale, and the mortality rate was brought down considerably.

It was, however, under the First Five Year Plan that the development work was taken up in a more systematic way. Under the Community Development Scheme, introduction and popularization of poultry keeping formed an important animal

husbandry developmental programme. There was emphasis on demonstrating that poultry keeping could be a profitable subsidiary occupation for the farmer if it were based on modern methods, and that the nutritive value of the customary poor diet of the people, could also be materially improved with the use of poultry products. As a result of the efforts made, the age-long prejudice against the keeping and consuming of poultry began to disappear, and the demand for eggs and improved birds soon out-stripped the available supplies. The resources of the State farms proved inadequate, and it soon came to be realised that if the pace of development was to be sustained, special measures would have to be taken to step up the production of improved varieties.

Towards the end of the First Plan period, the Union Ministry of Food and Agriculture also sponsored pilot scheme of poultry development in all the States. This scheme envisaged a study of the various problems confronting poultry production in rural areas and the formulation of a more comprehensive plan for the country in the light of the experience gained. Under the pilot plan, 33 Extension Centres were established throughout the country.

The question of expanding the supplies of improved birds has received particular attention in the Second Five Year Plan, which provides for an expenditure of Rs. 2-69 crores on poultry development schemes. It is proposed to establish five Regional Poultry Farms and 300 Development Centres in the breeding areas. Thirty thousand baby chicks offered by the U.S.A. under the T.C. M. aid for this scheme were flown to India where they were reared from three to eight weeks before being distributed to the various State farms. The consignment which consisted of different American strains of White Leghorn and Rhode Island Red breeds are being reared on these State Farms and would provide the nucleus of foundation flocks with which to stock the Development Centres. The Regional Farms would also serve as nuclei for feeding the States with suitable strains and breeds of poultry. To begin with, they would concentrate on acclimatising and multiplying birds of improved breeds which would be imported initially. Eventually, they would function as centres of research devising solutions for regional problems. The Development Centres would have demonstration farms, defertilization units, and custom hatching centres. Each centre

would serve a Poultry Development Block spread over several villages around it. Pure-bred birds will be supplied from these centres to selected breeders at subsidised rates. Improved cockerels will also be made available for upgrading the local stock. In addition, they would provide training to farmers in modern methods of poultry husbandry.

CHAPTER 50

FISHES

INDIA has, considerable fishery resources, but these have not been properly assessed so far. An extensive coastline of some 2,900 miles, a continental shelf of more than one lakh square miles in the Arabian Sea and the Bay of Bengal, and a large number of small oceanic islands form an extensive source of marine fish. Similarly, numerous rivers, streams, lakes, Jheels, artificial reservoirs and innumerable ponds, tanks and other water areas constitute a rich potential source of inland fish. But, on account of primitive fishing methods and inadequate facilities for storage, transport and marketing, the fishery resources are not being fully exploited or developed at present. Fishing in the seas is generally confined to a narrow belt of five-seven miles only, and the rich off-shore and deep-sea waters are left practically unexploited. Vast stretches of inland waters remain completely or partially fallow, and destructive fishing practices are often indulged in for lack of adequate conservation measures.

The population of adult fishermen in the country is of the order of five lakhs-and the number of fishing crafts, mostly primitive sailing boats, is about 75,000. The total production has been estimated at 12.3 lakh metric tons-71 per cent sea fish, and 29 per cent freshwater fish. On the basis of nutritional requirements of 3 oz. of fish per day, the fish-eating population of India needs 45.5 lakh metric tons. The annual-per capita consumption, is estimated at only 4.97 lb. which is much less than that obtaining in many other countries.

Consumption of fish varies in different parts of the country on account of: (a) disparities in fishery resources, (b) difference in food habits of people, and (c) economic factors. In the Saurashtra region of Gujarat a strong religious prejudice exists against eating fish. In the Punjab, fish is not very popular though there is no such religious taboo. In western U.P., Rajasthan and Madhya Pradesh, fish eating is generally confined to riverine areas. . In Bihar, West Bengal, Orissa, Kerala and Assam, on the other hand, fish is an important item of diet, while

in Andhra Pradesh, Madras, Mysore and Maharashtra a good proportion of the people would eat fish if they could afford it. Kerala leads in per capita consumption, followed by West Bengal. The lowest consumption is in the Punjab.

In the non-maritime States, fresh fish is in demand, while in maritime States both fresh and dried fish are consumed. Organised trade exists near centres of production and in urban areas, where people are comparatively well-off, while in vast tracts of rural areas no regular supplies are available. Only 43 per cent of the total production is consumed as fresh fish, nearly half the total production is dried and cured, the bulk being of sea fish. India exports annually nearly 6-0 lakh cwt. of fish, valued at Rs. 5-8 crores, mostly to Ceylon and Burma. Exports of frozen prawns to U.S.A. are now being actively promoted. About seven per cent of the fish produced in the country is converted into bye-products like fish manure, fish guano, fish oil, isinglass, etc.

PRINCIPAL FISHERIES OF INDIA

In the order of importance, the principal fresh water fisheries are those of: (1) Major Carps, (2) Cat-fishes, (3) Live fishes, (4) Prawns, (5) Mulletts, (6) Feather Backs, (7) Miscellaneous, including Minor Carps, Perches, Loaches, etc., (8) Eels, and (9) Herrings and Anchovies.

The marine and estuarine fisheries comprise the following major types in the order of importance: (1) Mackerels and Perches, (2) Herrings and Anchovies, (3) Miscellaneous, (4) Cat-fishes, (5) Jew fishes, (6) Silver-bellies, (7) Flat fishes, (8) Bombay Duck, (9) Mulletts, (10) Pomfrets, (11) Indian salmon, (12) Dorab, (13) Shell fishes, and (14) Eels.

FRESHWATER FISHES

I. Carps. These constitute 35.2 per cent of the freshwater fish catch. They feed generally on decaying aquatic vegetation and water animalcules. The major carps are fast growing and are well suited for stocking purposes. Their fry or spawn has to be collected from the natural breeding grounds in rivers and streams as they do not ordinarily breed in confined waters. The

minor carps are also utilized for fish culture, though not so extensively.

The more important varieties of carps are described below (a) *Labeo rohita* (Rohu). `Rohu' or `Rui' (as known in Bengal, Bihar, U.P. and Assam), `Rohi' (Oriya) and `Tapra' (Punjabi). The fish is found in major rivers of Bengal, Uttar Pradesh, Assam, Bihar, Orissa and the Punjab. It is a column-bottom feeder, and grows to three feet or more in length. It is very popular as a food fish.

(b) *Labeo calbasu* (Kalbasu). `Kalbasu' or `Kalbaus', (as known in Bengal, Bihar and U.P.), 'Mahlee' (Assamese), `Kalabainsi' (Oriya), `Kalahan' (Punjabi), `Kakkameen' (Tamil), and 'Nalla Gandu meenu' (Telugu). It is relatively slow growing and attains a size of about three feet. It is found in major rivers throughout India except Malabar.

(c) *Catla catla* (Catla). `Catla' (as known in Bengal, Bihar, and U.P.), `Bhokua' or `Bahu' (Assamese), `Bhakur' (Oriya), `Thaila' (Punjabi), `Bocha' (Telugu), `Thoppameen' (Tamil), and `Karakatla' (Malayalam). It is found in the major rivers of the Punjab, Bengal, Uttar Pradesh, Assam, Bihar, Orissa, Andhra Pradesh and in the Cauvery river in Madras. It is a surface feeder and is the fastest growing carp fish in India. It is quite popular when not exceeding two feet in size. The larger specimens, reaching up to six feet, are coarse.

(d) *Cirrhina mrigala* (Mrigal). `Mrigal' (Bengali), `Mrika' (Assamese), `Mirikali' (Oriya), `Naini' (in Bihar and U.P.), `Mori' (Punjabi) and `Yernmeenu' (Telugu). It is found in the major rivers of the Punjab, Bengal, U.P., Bihar, Assam, Orissa and Andhra. The fish is a bottom feeder and grows to three feet or more.

(e) *Labeo kontius* (Cauvery Carp). `Karimulle', or `Kalchel' (Tamil). It is found only in the Cauvery river system. The maximum size is two feet.

(f) *Labeo fimbriatus* (Frige-lipped Carp). `Chel Kendai' (Tamil), `Gandu meenu' (Telugu), `Bahrum' (Oriya), and `Tambra' (Marathi). It is found in the major rivers of South India except Malabar. The maximum size is two feet.

(g) *Cirrhina cirrhosa* (White Carp). `Yenkendai' (Tamil). It is found in the Cauvery river system, where it is the most abundant carp: It reaches a size of two feet.

(h) *Labeo gonius*. `Goni' (Bengali), `Kursha' (Oriya), and `Kurhi' (Assamese). It is found in major rivers of the Punjab, Bengal, Orissa, Assam, U.P. and Bihar. The maximum size is over two feet.

(i) *Labeo nandina*. `Nandin' (Bengali). It is found in the rivers of North Bengal and Assam, and attains a size of about three feet at the most.

(j) *Labeo bata* (Bata). `Bhangan bata' (in Bengal, Bihar and Assam), `Rajpodah' or `Rajbata' (Oriya). It is found in the rivers of Madras, Orissa, Bihar, Bengal and Assam. It grows slowly, and the maximum size attained is about two feet.

(k) *Labeo dussumieri*. `Thooli' (Malayalam). It is found in the rivers of Malabar and Kanara, and attains 11/2 feet length.

(l) *Cirrhina reba* (Reba). `Arinjan' (Tamil), `Podah' (Oriya), and `Khorkebata' (in Bengal and Bihar). It is found in rivers throughout India except Malabar. Maximum size attained is one foot.

(m) *Osteochilus thomassi*. `Nagendram' (Telugu). It is found in the rivers of Andhra and reaches a size of about two feet.

(n) *Thynnichthys sandkhol*. `Ahku chappal' (Telugu). It is found in Godavari and Krishna rivers and attains 11/2 feet size.

(o) *Pwattius carnaticus* (Carnatic Carp). `Pauri' (Tamil). It has a restricted distribution in the rivers along the foot of the Nilgiris and the South Kanara hills and in the Cauvery river system. It reaches a size of over two feet, though the growth is somewhat slow.

(p) *Tor* for (Mahaseer). `Mahasir' (Punjabi), `Kajra' (Oriya), `Mahsala' (Marathi) and `Kendi' (Tamil). It is found throughout India though it is particularly abundant in streams and rivers with a rocky bed. Immature specimens up to a few inches in length would be met with in any clear gravelly stream. The fish grows up to 51/2 feet in length. It is a premier sporting fish of India. It travels towards the head waters at the beginning of rains, and travels down streams afterwards.

(q) *Puntius sarana* (Olive Carp). `Kuruka' (Malayalam), `Panjelli' (Tamil), `Kannaku' (Telugu), `Sarana' (Bengali and Oriya), `Potah' (in -U.P.), `Sennee' (Assamese), `Jundoori' (Punjabi) and `Kudali' (in Bombay). It is widely distributed, and

is found in most of the rivers of the country. It does not, however, grow very fast.

(r) *Puntius dubius*. 'Kozhimeen' (Tamil). It is found in the Cauvery river system and reaches about two feet in size.

(s) *Acrossochilus hexagonolepis* (Chocolate Mahaseer). 'Karambai' (Tamil), 'Katli' (Bengali) and 'Bokar' (Assamese). Indigenous to the Himalayan streams in Assam and Bengal. It is also found in the river Cauvery. It reaches a size of over two feet and is an excellent sporting fish.

(t) Exotic and Transplanted Fishes. 'Three species of trout (*Salmo*), one species of Top Minnow (*Gambusia*), two species of perch: Gourami (*Osphronemus*) and Tilapia (*Tilapia*) and some carps (*Cyprinus*, *Tinca*, etc.) have been introduced in Indian waters for sport, larvicidal and pond culture purposes. These are as follows:

1. Rainbow trout, *Salmo indeus*, introduced into Ootacamund, Madras, in 1867 from Europe.
2. Brown trout, *Salmo fario*, introduced into Kashmir (1901) and Kulu Valley (Punjab 1901) from Europe.
3. Golden or Crucian Carp, *Garassius vulgaris*, introduced into Ootacamund, Madras, in 1874 from Europe.
4. Tench, *Tinca tinca*, introduced into Ootacamund, Madras, in 1874 from Europe.
5. European Carp, *Gyprinus carpio*, introduced into Ootacamund Madras, in 1939 from Ceylon.
6. Gourami, *Osphronemzts gorami*, introduced into Madras, in 1926 from Mauritius and Java.
7. Tilapia, *Tilapia mossambica*, introduced in experimental tanks at Mandapam, in 1952 from Bangkok.
8. Scale Carp, *Cyprinus carpio* var. *communis*, introduced in Research Station's tank at Cuttack, in 1957, from Bangkok.

The Golden Carp, the Tench and the European Carp have taken well to the upland waters of the Nilgiris, Kumaon and Himachal Pradesh. The European Carp and Tench have also been found to thrive well in plains. Regional transplantation of Catla from Godavari and the Krishna to the Cauvery and of Rohu from Bengal and Orissa to Madras has been carried out with

success. Culture of Tilapia is permitted in a few selected areas; west of Western Ghats, and coastal strips between Cape Comorin and south of and excluding river Tapti and in the districts of Tirunelveli, Madura and Ramnad. Culture of Scale Carp has been permitted throughout India. The fish can be cultured along with other major carps of India.

II. Cat-fishes. The variety derives its name from its barbels (feelers). Some species, called 'live fishes', have accessory respiratory organs and can live outside the water for an appreciable period. Cat-fishes form 32-9 per cent of the total freshwater fish catch. Some of the important varieties are given below:

(i) *Wallago attu* (Freshwater shark). 'Malli' (in Delhi and Punjab), 'Attu-Vala' (Malayalam), 'Boal' (Bengali), 'Boali' (Hindi), 'Borali' (Assamese), 'Baliah' (Oriya), 'Valai' (Tamil) and 'Wallaolh' (Telugu). It is found in rivers, lakes and ponds throughout India. It is a predacious piscivorous fish, and grows to a size of about six feet. It is a good game fish.

(ii) *Bagarius bagarits*. 'Goonch' (in U.P.), 'Nutanda' (Marathi), 'Bagh-Air' (Bengali), 'Pathar chata' (Oriya), 'Goreah' (Assamese) and 'Rahti Jellah' (Telugu). It is found in all the large rivers in India. It grows up to six feet in size and is probably the largest fish caught on rod and line in India.

(iii) *Pangasius pangasius*. 'Pangas' (Bengali), 'Coola kelathi' (Tamil) and 'Jellum' (Oriya). It is found in all the large rivers and estuaries of India. It is a foul feeder and reaches more than four feet in length.

(iv) *Silonia silondia* (Silond). 'Silun' and 'Dhain' (Bengali), 'Sdond' (Punjabi), 'Jolong' (Oriya), 'Poonathe' (Tamil) and 'Wanjou' (Telugu). It is very common in Gangetic estuaries, and prefers strong streams and clear deep waters. It grows to a size of six feet, and is considered good for eating.

(v) *Mystus seenghala* (Singhala). 'Air' (Bengali), 'Tengra' (in U.P.), 'Addi' (Oriya), 'Seengala' (Punjabi) and 'Cumboo kelathi' (Tamil). It is found in rivers and lakes throughout India, and attains a length of over four feet.

(vi) *Eutropiichthys Vacha* (Vacha). 'Bachwa' (Punjabi) and 'Bacha' (Bengali). It is found only in the rivers of North India. It is a game fish, growing to about 14 feet in size.

III. Feather-backs. *Notopterus chitala*: ` Chital ' (Bengali), ` Seetul' (Assamese), ` Moh' (Punjabi) and ` Chitul' (Oriya). The fish attains a length of over four feet. It is much esteemed as a food fish though it is full of small bones.

IV. Live Fishes. The ` Live Fishes' form ten per cent of the fresh water fish catch. The important varieties are as follows

(i) *Chrias batrachus* (Magus). ` Mushi ' (Malayalam), ` Avai' (Tamil) and ` Magus ' (Bengali). It is found in swamps and ponds through-out India. As food, it is highly nutritious. It is amphibious and grows to about 1 1/2 feet in size.

(ii) *Heteropneustes fossilis* (Singhee). , ` Singi' (in Bengal and U.P.), `Kaari' (Malayalam) and `Teli' (Tamil). It is found in swamps and ponds throughout India. An amphibious fish, it attains a size of 1 1 feet.

(iii) *Anabas testudineus* (Climbing Perch). `Koi' (Bengali and Assamese), ` Kou ' (Oriya), ` Kobhai ' (Bihar), ` Undeecolle ' (Malayalam) and ` Sennal' (Tamil). The fish has an air-breathing system which enables it to live for a long time out of water. It attains a length of about eight inches.

(iv) *Channa marulius* (Large Murrel). ` Shel' (Bengali). It is the largest of all the murrels and is found almost throughout India, mcst common in lakes, reservoirs and swamps. It is highly predacious even cannibalistic. It attains a length of about four feet.

(v) *Channa striatus* (Common Murrel). ` Shole' (in Bengal and Bihar), ` Seulo ' (Oriya), ` Brral ' (Tamil) and ` Verral ' (Malayalam). This fish has also plate-like scales on the head and is referred to as snake headed. It is found throughout the plains, especially in swamps and grassy tanks. It is a valuable food fish, and reaches about three feet in length.

(vi) *Anguilla bengalensis* (Eel). A freshwater species-` Ahir' (Marathi) and ` Vellangoo ' (Tamil). It is an irritable creature, with snake-like body. It attains a length of four feet.

Some food fishes have been found suitable for cultivation in ponds in India. Their cultural value varies considerably, depending as it does on their relative growth, size, adaptability to different types of waters, and easy availability of seed.

They include fishes from the following groups

(1) Carps: *Catla catla*; *Labeo rohita*; *Labeo calbasu*; *Labeo finzbriatus*; *Labeo koaZtius*; *Labeo gonius*; *Labeo*

nandina; Labeo bata; Labeo sp.; Labeo dussumieri; Cirrhina mrigala; Cirrhim cirrhosa; Cirrhina reba; Osteochibis thomassi; Thynnichthys sandkhol; Puiztius carnaticus; P. dubius; Acrossochilus hexagoizolepis; Cyprinus carpio; Carassius vulgaris and Tinca tinca.

(2) fat-fishes: Wallago attu and Mystus seenghala.

(3) Mulletts: Ahluil cephalus; Mugil corsula and Mugil sp.

(4) Perches; Etroplus suratensis; Osphronemus gorami and Lates calcarifer.

(5) Live Fishes: Heteropneustes fossilis; Clarias batrachus; Anabas testudineus; Channa marulius and C. Striatzts.

(6) Others: Chams chanos and Megalop cyprinoides.

ESTUARINE AND MARINE FISHES

I. Cat-fishes. These form one of the most important variety of estuarine and marine fishes.

(i) Tachysurus dussumieri (Marine cat-fish). ` Shinghala' (Marathi), ` Mandai keleru ' (Tamil) and ` Jedi jella ' (Telugu). It is common on the West Coast of India, and grows to about two feet in size. It is salted and dried extensively.

(ii) Tachysurus sona. ` Khago ' (Sindhi), ` Keluthi ' (Tamil), ` Etta' (Malayalam) and ` Jellalu ' (Telugu). It is commonly found along the Bombay coast, and occasionally ascends tidal rivers. It attains three feet size.

II. Mulletts. These are distributed throughout the Indian seas, and are found in the tidal rivers and streams also. The freshwater forms are confined to large rivers such as the Ganges and the Jamuna. They are also cultivated in water tanks and ponds, and are salted and dried extensively. ,

(i) Mugil cephalus. ` Bhangan ' (Bengali), ` Khonga ' (Oriya) ` Thirutha' (Malayalam), ` Madavi' (Tamil) and ` Moyya' (Telugu). It is found in the coastal sea and backwaters throughout India. It attains a size of three feet.

(ii) *Mugil speigleri*. ` Bhangana ' (Bengali), ° Madavi ' (Tamil) and `Moyalu' (Telugu). It is a marine form, and attains a size of 10 to 14 inches.

(iii) *Rhinomugil corsula* : ` Khorsula ' (Bengali), I Undala ' or Andwari' (Hindi), ' Kekunda' (Oriya) and `Hurdwahre' (Punjabi). It is found in estuaries and rivers of Bengal, Assam, Bihar and Orissa. The eyes pop out of the skin, and it swims keeping them above the surface of water. When disturbed it dives immediately. It attains a size of 12 inches or more.

III. Dorab or Silver-bar Fish. It is known as ` Vala' in Malayalam, ` Kulluvala ' in Telugu, ` Karli ' in Marathi and ` Valai ' in Tamil. It is caught all along the Indian coastline. It attains a size of 12 feet. Dorab fishing is particularly important on the east coast of Madras and is at its peak in June.

IV. Herrings. Herrings are abundant in the seas of India and are important for their oil. They are more numerous on the Malabar than on the Coromandel Coast. They swim in shoals near the surface generally, feeding on plankton. The important varieties are described below

(i) *Hilsa ilisha*. (Hilsa). ` Ilish' (Bengali), ` Illisha' (Oriya), ` Pala' (Marathi), ` Palasah' (Telugu), and ` Ullam' (Tamil). It is an estuarine fish which goes up the rivers during floods for spawning. It is an important species in the estuarine regions of Sabarmati, Cauvery, Krishna, Godavari, Mahanadi, Ganges, Nerbada and Tapti. A regular Hilsa fishery exists in the Chilka Lake. Though in the rivers, Hilsa fishing commences generally after the monsoon rains, in the estuaries of the Ganges and the Mahanadi it is continued during the winter and summer months also.

(ii) *Sardinella longiceps* (Oil Sardine). ` Torli' (in Bombay), ` Haid' (Marathi), `Chalai' (Tamil) and `Kavallu' (Telugu). It appears in large shoals along the Malabar Coast, but its movements are uncertain. Fishing starts immediately after the commencement of the South-West Monsoon, and lasts from August to March, September-December period being the peak season. The Oil Sardine fishing appears to be related to the yield from some other fisheries, notably of Mackerel, a good year for the one generally coinciding with failure of the other. The adult fish contains 10 to 15 per cent oil. By boiling the fish with water

in large cauldrons, the oil is separated and recovered. The cooked fish scrap when dried is called 'guano' and is sometimes converted into fish meal for cattle and poultry feeds. Some sardines are canned, but generally the fish are salted and cured or pickled with vinegar and spices.

(iii) *Sardinella fimbriata* (Lesser Sardine). ` Khaira ' (Bengali); ` Pedwa ' (Marathi), ` Sudai ' (Tamil), ` Chala-mathi ' (Malayalam) and ` Kavallu ' (Telugu). It is also a shoaling pelagic fish, and is caught along both the Eastern and Western Coasts. On the Coromandel Coast it appears during the summer. It does not become 'fat' like Oil Sardines.

(iv) *Sardinella albella*. It is common on the West Coast chiefly in the Palk Straits.

(v) *Chanos chanos* (Milk Fish). ` Poomeen ' (in Kerala), ` Kuzhal ' or ` Paalmeen' (in Madras) and ` aaluchappa kanisalu' (in Andhra). It is one of the common marine fishes frequently occurring along the coast, in estuaries and in backwaters. Chanos fry are collected in considerable number from coastal creeks, particularly in the Gulf of Manner, and stocked in inland freshwaters.

V. Anchovies. It is an important class of fish found along the coast.

(i) *Setipinna purava*. ` Poruva ' (Tamil) and ` Poravalu ' (Telugu). The fish is 10 to 12 inches long and has oily flesh. It is preserved in oil mixed with spices, and is also made into paste. It is caught in fairly large quantities all along the coast.

(ii) *Seetipinna telara*. ` Phansa ' (Bengali), ` Bindi ' (in Bihar) and ` Kati' (Marathi). It attains a size of 16 inches. The species is more common in Orissa and Bengal coasts.

VI. Bombay Duck Group. *Harpodon nehereus*. ` Bombil ' (Marathi), ` Nehare ' (Bengali), ` Bummili ' (Malayalam), ` Vangaravasi ' (Tamil) and ` Vanamattalu ' (Telugu). This is a shoaling pelagic fish, more or less localized in Western Coast from Ratnagiri to Broach, beyond which it decreases in number. The fishing season begins towards the end of September, just after the South-West Monsoon, and remains in full swing up to the end of January. The species is carnivorous, its main food being prawns. It seems to be migratory, for it moves away from the shoie sometimes in February-March and reappears in big

shoals in October. It attains 16 inches in length. It is cured by drying and is highly esteemed as food whether fresh or salted.

VII. Mackerels and Perches. Mackerels and Perches constitute as much as 21-7 per cent of the total marine fish production of India. Important varieties are given below

(i) *Rastrelliger kanagurta* (Indian Mackerel). 'Aila' (Malayalam), 'Kanagurta' (Telugu) and 'Kaulu gedar' (Marathi). It is a shoaling pelagic fish. The shoals arrive in shore during certain seasons, but their movements are uncertain. Along the West Coast; the fish is caught from Ratnagiri in Maharashtra to Cape Comorin in the South. On the East Coast, Ganjam is the northern limit of occurrence. The fishing season on West Coast is from October to January and may extend to March. On the East Coast, the fishing season lasts from July to October on the Andhra Coast and from September to April on the Coromandel area. Important Mackerel fishing tracts are Konkan, North and South Kanara and Malabar, and the chief fishing centres are: Ratnagiri, Malavan, Karwar, Malpe, Tellicherry, Calicut and Cochin. The fish is extensively salted and dried in Malabar. It can also be canned in oil.

(ii). Seer fishes. Seer fishes occur all along the coast and are especially abundant near the estuaries of large rivers: They are excellent for eating, but large specimens become coarse. The important species are as follows

(a) *CYBIUAT GUTTATUM*. 'Bijram' (Bengali), 'Towar' (Marathi), 'Vanjiram' (Tamil), 'Vanjaramu' (Telugu) and 'Varimeen' (Malayalam). It swims near the surface and grows up to six feet in size.

(b) *CYBIUM COMMERSONI*. 'Seir' (Bengali), 'Tuvor anjari' (Marathi), 'Seela' (Tamil), 'Yellari' (Telugu) and 'Ayakora' (Malayalam). The fish grows to about five feet in size. It is often 'light cured' in slices.

(iii) Sea perches. The main species are as follows

(a) *L. ATT, S. CALCARIFER* (Cock-up or Becti). 'Bhetki' (Bengali), 'Khajura' (Marathi), 'Koduva-' (Tamil), 'Narimeen' (Malayalam) and 'Panduchapa' (Telugu). It is found throughout the seas of India, and is specially abundant near the estuaries of large rivers. It is much esteemed as a food fish, and fetches the highest price in city markets. It grows to a size of five feet, but

the usual market size is 12 feet. Its air bladder is dried for isinglass.

(b) ETROPLUS SURATLINSIS (Pearl spot). ` Karimeen' (Malayalam), ` Sethakendai ' (Tamil), ` Duvvene chapa' (Telugu) and ` Kundal' (Oriya). It is common in brackish waters along the coast of Malabar and on the East Coast up to Orissa. Its favourite places are shallow creeks of backwaters and canals where there is luxuriant aquatic vegetation. The fish is also well suited for stocking in freshwater tanks and lakes. The fish attaches its eggs to submerged hard objects like bricks stones, logs, etc,

and guards its young ones. It breeds almost throughout the year. The maximum size is about 18 inches.

(iv) Cut-lass or Ribbon fish (Hair tails). The most important species is *Trichiurus haumela*. ` Bala ' (Marathi), ` Thalayan ' (Malayalam), ` Savalai ' (Tamil) and ` Savallu ' (Telugu). These shoaling fish are important in Madras, Kerala and adjoining areas. They appear between the months of June and October, and constitute up to 40 to 45 per cent of the total fish landings during the peak periods. They are easily sun-dried with salt: The fish is known to devour its own species and is very voracious. It grows to a size of three to five feet.

(v) Horse mackerel. The main species of this class of fish is *Caranx Crumenophthalmus*. ` Labi' (Marathi), ` Para' (Malayalam and Telugu) and ` Parai' (Tamil). It is a pelagic fish arriving in vast shoals in the months of September and October on the West Coast of India. Large quantities are salted and dried. The fish attains a length of about a foot.

VIII. Silver-bellies. These small fishes are extensively sun-dried in India. They are thin and bony, and can be satisfactorily cured by soaking in sea water and drying in the open air.

The most important species is *Leiognathus splendens*. ` Surgatta ' (in Bombay), ` Katali ' (Marathi), ` Karal ' (Tamil), ` Mullan ' (Malayalam) and ' Karalu' (Telugu). It is caught in very large numbers on the Malabar Coast in the months of August-September and May June. The fish attains a size of five to six inches in length. Salted silver-bellies, known as ` Caraputty ' in Malabar are reputed to be good for patients suffering from malaria.

IX. Pomfrets. The important species of this class are given below:

(i) *Stromateus cinereus* (Silver Pomfret). ` Chanda' (Bengali), ` Saranga ' (in Bombay), ` Chandava ' (Marathi), ` Vellavoli ' (Malayalam), ` Vavval ' (Tamil) and ` Chenduvallu ' (Telugu). It grows to about a foot in length. Fishing commences by about October in Bombay Coast. The shoals appear to migrate southwards after February and pomfrets become plentiful in South Kanara Coast between March and April and further South in the Malabar Coast between July and August. A similar southerly migration seems to take place on the East Coast also. Pomfrets are plentiful in the northern part of the Bay of Bengal in January and February, and in Madras only between June and November.

(ii) *Stromateus sinensis* (White pomfret) is the commonest pomfret in Madras market. It is also quite plentiful on the Bengal coast. It is considered to be the most delicious variety.

(iii) *Stromateus niger* (Black pomfret). `Kaula' (Marathi), `Karapu avoli' (Malayalam) and ` Karapu vavval' (Tamil). It is similar to *S. cinereus*.

X. Flat Fishes (Soles and Tongue Fishes). The, flat fishes prefer sandy or gravelly shore but are fitful in their migration. They seem to appear at certain spots, almost at a fixed time every year, but in other seasons disappear as suddenly as they arrive. *Plagusia bilineata* is a typical example. All the species are edible and esteemed as food although those from deep waters are generally rated higher. The flesh is of excellent flavour.

XI. Indian Salmons (Thread Fins). Some of the well-known species of this class are described below: °

(i) *Eleutheronema tetradactylus* (Indian Salmon or thread fin). ` Sahal' (Bengali), ` Rawas' (Marathi), ` Kala' (Tamil), ` Maga ' (Telugu), and ` Bameen' (Malayalam). It is widely distributed along the coastline, and is also known to ascend high up in river's. The fish grows to a size of six feet and above. It is excellent for eating, and can be salted nicely. The fish maws are used for preparing isinglass.

(ii) *Polydactylus paradiseus* (Mango Fish). ` Tupsee mach' (Bengali), and ` Dodywa rawas ' (Marathi). It is found in

fair abundance in the estuaries. In the Hooghly river it ascends up to about 150 miles from the sea for breeding, from April to June, when it is caught in large numbers. It attains a size of nine inches. It is considered a special table delicacy.

XII. Jew Fishes. One of the most important species of this class is

Pseudosciaena diacanthus. 'Ghol' (in Bombay), 'Kora' (Malayalam), 'Kathalai' (Tamil) and 'Gorsalu' (Telugu). It attains a size of five feet, and is a good trawler fish. It is eaten both fresh and salted, and isinglass is prepared from its air bladder.

XIII. Elasmobranchs. This includes sharks, sawfishes, skates and rays. The flesh is coarse, and is eaten mostly by poor people. Gelatine and glue are obtained from the fins. The fins (excluding the caudal) are cut at roots to remove flesh, treated with slaked lime and sundried. These constitute the shark-fins of commerce which are exported in large quantity to China.

(i) Sharks. Sharks are found throughout the year, but the main fishing season generally lasts from July to March on the West Coast, and from May to January on the East Coast. The principal fishing areas are: Kathiawar, Bombay, Kanara, Malabar and Kerala coasts; southern and northern sections of the East Coast of Madras and West Bengal. Sharks usually come with sardines and mackerels. A good season for these fishes mean a good shark season also. The most important aspect of exploitation of sharks is the extraction of shark liver oil. A comparatively small proportion of the catch is consumed fresh locally, the bulk being filleted, saltcured and sun-dried.

The important varieties of sharks are as follows:

(a) *CARCI3ARHINUS GANGETICUS*. (Ground Shark of rivers). 'Hangar.' (Bengali), 'Sravu' (Malayalam), 'Saura' (Tamil) and 'Sorrah' (Telugu). It is very common in the Bay of Bengal and goes up to the rivers also.

(b) *GALEOCERDO RAYNERI*. 'Kettalum' (Telugu), 'Pullian sravu' (Malayalam) and 'Wulluven sorrah' (Tamil). It attains a considerable size in the Indian seas. It is exceedingly fierce and eats everything, even sea snakes.

(c) *SPHYPNA BLOCHII*. (Hammer-headed shark). 'Kanere' (Marathi), 'Sappa sorrah' (Telugu), 'Komban sorrah' (Tamil) and 'Kannankodi' (Malayalam). It is the commonest

shark on the West Coast. The head is hammer-shaped. The fish rarely exceeds four feet in length.

(ii) Sawfish. The head and skull are prolonged into a long flattened 'rostrum', lateral edges of which are armed with a series of strong teeth. The flesh is of about the same quality as that of the shark. The fins are processed, and the liver oil is also extracted. The Indian species are known to ascend even rivers beyond the tidal influence:

The most important species is *Pristis cuspidata*. 'Kandere' (Marathi), 'Vela meen' (Tamil), 'Yahla' (Telugu) and 'Vallu sravu' (Malayalam). It ascends rivers in search of food. The snout is flat and protruding, and the fish can cause great havoc with it. The largest size recorded of this species is 14 feet.

(iii) Skate. The head is generally flattened and has a wedge-shaped outline. Skates are very common in Indian seas during cold weather. They are used as food by poor people only.

The principal species of this class is *Rhynchobates djeddensis*: 'Ranja' (Marathi), 'Palunga' (Tamil), 'Tipi ulavi' (Telugu), 'Varithalai' (Malayalam) and 'Lang' (in Bombay). It is considered nutritious. It attains six feet length. It is caught in large numbers along the East Coast in March.

(iv) Rays. Rays are shallow water forms, and are most plentiful at depths of 10 to 15 fathoms, though they are also found in fair numbers up to 25 fathoms. They are dreaded by fishermen as they are capable of inflicting grievous wounds with their caudal spines. The skins yield an inferior type of shagreen, and are used as substitute for sandpaper. Oil is extracted from the liver.

The most common species of this fish is *Dasyatis* spp. (Sting ray). 'Goval paket' (Marathi), 'Wolga tankee' (Telugu) and 'Neitherandi' (Malayalam). It is very common during the South-West Monsoon period when it moves towards the shore: It grows to about six feet round the disc.

XIV. Eels. Eels resemble snakes. They are voracious and carnivorous. They are not usually eaten in India, but are recommended as diet for invalids.

The most important species is *Alluraenesox talboides*—a marine form 'Bam' (Bengali), 'Warn' (Marathi) and 'Pambumeen' (Malayalam). It grows to a size of six feet. Its fishing is popular in Bombay.

XY. Crustaceans. The majority of crustaceans are marine and include prawns, crabs, shrimps and lobsters. Practically, all species of prawns and crabs are edible and form 10 and 7-5 per cent respectively of the total fish catch. About 40 per cent of the total production of marine crustaceans comes from Kerala State. Bengal contributes approximately 30 per cent; and the remainder is produced by other maritime States, such as Orissa, Madras and Maharashtra.

Prawns. Important species of prawns are: (i) *Penaeus carinatus*; (ii) *Penaeus indicus*; (iii) *Metapenaeus monoceros*; (iv) *Metapenaeus dobsoni*; (v) *Leander styliferous* and (vi) *Palaemon carcinus* (a freshwater spp.). *P. carinatus* is the largest species, and is caught in considerable numbers from the sea as well as from estuaries and backwaters. *Metapenaeus* are much smaller. *M. dobsoni* is the most important species in Kerala area. ,

Crabs. 'Crab curry' is supposed to be good for asthma. The largest catches of crabs on the Bombay coast are reported from August to October, and in Madras from March to June. The following species are important:

(i) *Scylla serrata* (Marine). 'Novakankara' (Bengali) and 'Nandu' (Malayalam and Tamil). It is the common edible crab, abundant in estuaries and backwaters. It is caught from June to August.

(ii) *Neptunus pelagicus* is found mostly in the sea along the Southwest coast or in brackish waters from February to May.

(iii) *Paratelphusa spinigera* is the commonest freshwater crab of Bengal and is found near tanks, wheels and rivers.

Shrimps. Species of genus *Acetes* occur in large numbers in coastal water.

Lobsters. Spiny lobsters, *Panulirus polyphagus* and *P. ornatus*, and squat-nosed lobsters *Thenus orientalis* are commercially valuable. The former are caught in fair numbers on Bombay coast from November to March, and the latter from Point Calimere to Cuddalore.

XVI. Molluscs. The entire littoral and sub-littoral zones of the East and West Coasts, the innumerable reefs, creeks and gulfs and the multitude of small and large estuaries and backwaters abound in rich molluscan fauna. Molluscs are used as food by the poor classes.

Pearl oysters in Indian waters belong to *Pinctada* species of which *P. vulgaris* forms large beds of great commercial value in the Gulf of Mannar, Palk Bay and Gulf of Kutch. The pearl banks are situated in 10 to 12 fathoms deep waters up to about 1.2 miles from the shore. The oysters grow to a size of about- 32 to 4 inches, and live not beyond five years. Exploitation of pearl fisheries by divers is conducted under State supervision.

The important forms are as follows

Chanks. Chanks are gregarious inhabit- and occur in large numbers on the muddy sand bottom of waters up-to about .seven fathoms deep They are fished by diving, in the Tirunelveli, Ramnad, South Arcot and

Tanjore districts of the Madras State on the East Coast, and in Kerala and Kathiawar on the West Coast.

Edible shelNyh. Oysters, clams, mussels, cockles and a few gastropods and cephalopods are used as food throughout the country. Of the edible oysters the most important are the backwater oysters.

Ostrea madrasensis abounds in all the estuaries and backwaters of the East and West Coasts. The green sea mussel, *Mytilus vindus* occurs along the Madras, Malabar, Kanara, Cochin and north Kerala coasts.

Clams-*Meretrix* spp. form vast beds in estuaries and backwaters of the country, and are of considerable food value.

Of the marine gastropods, *Xancus marmoratus*, *Thais* sp., *Strombus* sp., *Natica* sp. and *Tonna dolium* are utilized as food. Of the freshwater gastropods, only the apple snail, *Pila globosa*, is used for food..

Among cephalopods the squids of the genus *Loligo*, the Cuttle fish *Sepia* and the Devil fish *Octopus* are eaten, more particularly in Ramnad district of Madras State where they occur in abundance in Palk Bay.

DEVELOPMENT OF FISHERIES

The development of fisheries in India started on an ad hoc basis under the ,post-war Grow More Food Schemes. It was, however, under the First Five Year Plan that the work was undertaken on a comprehensive scale. Steps were taken to increase the production and utilization of fish by establishing

Fisheries Research Stations and initiating schemes for training fishery workers and fishermen, development and conservation of freshwater fisheries, stepping up exploitation of sea fisheries, and improving fish marketing and fish utilization. These activities have been further expanded in the Second Five Year Plan. An increase of 10 per cent in fish production is estimated to have taken place by the end of the First Plan period, and it is expected that under the Second Plan the production would go up by 33 per cent.

Development of inland fisheries entails surveys of culturable waters, increasing the extent of such waters by repairing and reclaiming derelict tanks and marshy areas, increasing the availability of fish-seed of suitable species, stocking to the maximum possible extent and the rational exploitation of fisheries. Activities on these lines have been undertaken in almost every State. Development of reservoir in the multi-purpose river valley projects has also been initiated. The Central Indian Fisheries Research Station, Barrackpore, and its sub-stations are undertaking investigations on various developmental problems.

For increasing production of sea fisheries, efforts are being directed towards providing necessary fishery requisites to the fishermen and improving their economic conditions, and mechanization of fishing operations. Mechanized fishing with powered crafts has been introduced along two lines: (a) increasing the operational range of existing craft by installing engines and mechanical devices; (b) introducing off-shore fishing by undertaking exploratory fishing with powered vessels that have proved successful elsewhere. ,

Exploratory fishing has been taken up at the Central Deep Sea Fishing Stations at Bombay, Cochin, Tuticorin and Visakhapatnam and by the Government of West Bengal, and modern fishing methods such as, ottertrawling, bull trawling, shrimp-trawling, seining, ring netting, long-lining, gill-netting, drift-netting, etc. are being tried. With the integrated programme for development of in-shore and off-shore fishing, a firm foundation is being laid for modern powered fishing industry in India.

The Central Marine Fisheries Research Station, Mandapam, and its sub-stations and the Central Fisheries Technological Research Station, Cochin and Ernakulam are

undertaking investigations on various problems connected with the development of marine fisheries. The Central and maritime State Governments have established a dozen centres for training fishermen in methods of mechanized fishing. Measures are also being undertaken to improve fish marketing and fish utilization.

STATISTICAL APPENDIX

STATISTICAL APPENDIX

TABLE I. CLASSIFICATION OF AREA (1956-57)

States and Union Territories	Area ac- cording to vill- age papers (Report- ing area)	Forests	Area not available for cultiva- tion	Other unculti- vated land ex- cluding fallow lands	Fallow lands	Net area Net sown thousand	area irrigat- ed acres
1. Andhra Pradesh	66,502	13,726	10,159	8,108	6,403	28,106	7,068
2. Assam (including NEFA)* ..	35,764	12,042	14,077	3,638	889	5,118	1,533
3. Bihar ..	42,823	9,676	5,299	2,692	5,966	19,190	4,384
4. Bombay (P) . .	1,20,876	15,486	19,260	11,226	7,679	67,225	3,616
5. Kerala ..	9,412	2,459	1,000	1,066	362	4,525	829
6. Madhya Pradesh ..	1,07,589	33,443	11,555	18,405	5,834	38,352	2,049
7. Madras ..	32,020	4,419	5,564	3,485	4,138	14,414	5,517
8. Mysore ..	46,155	6,650	4,121	7,081	3,405	24,898	1,829
9. Orissa* ..	38,401	8,799	6,274	6,466	3,008	13,854	2,414
10. Punjab ..	30,287	926	7,817	2,110	1,326	18,108	7,459
11. Rajasthan ..	84,450	3,553	14,833	21,626	13,736	30,702	3,490
12. Uttar	72,543	8,826	10,984	7,313	3,607	41,813	11,420

Pradesh ..

13. West (c) (c) 3,269 1,748 1,448 12,825 3,009
Bengal (P) 21,815 2,525

14. 5,923 1,398 1,637 619 591 1,678 743
Jammu &
Kashmir
(d)

Total 7,14,560 1,23,928 1,15,849 95,583 58,392 3,20,808 55,360
States

Union
Territories

15. Delhi .. 366 4 85 48 12 217 79

16. 2,971 522 179 1,543 48 679 94
Himachal

Pradesh

17. 346 37 (b) 85 (a) 224 145

Manipur

18. 2,634 1,573 96 447 36 482 4

Tripura ..

..

19. 87 35 16 15 2 19 ..

Andamans
& Nicobar
Islands ..

..

20. 7 .. (a) (a) .. 7 ..

Laccadive,
Minicoy
and
Amindivi
Islands

Total . 6,411 2,171 376 2,138 98 1,628 322

Union
Territories

..

Total India 7,20,971 1,26,099 1,16,225 97,721 58,490 3,22,436 55,682

..

*- Due to non-receipt of 1956-57 data, figures for 1954-1955 have been repeated. In case of Assam the latest available data are for year 1953-54.

(a) Below 500 acres.

(c) The figures are provisional and estimated after certain adjustments. They, therefore, do not tally with the figures given in the State Season and Crop Reports.

(d) Excludes figures for the Pakistan-occupied portion of the State.

(P) Provisional.

(b) Included under column Forests.

Source : Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi.

TABLE 2. GEOGRAPHICAL AREA, POPULATION AND NET AREA SOWN

States and Union Territories	Geographical area (Square miles) (According to reorganised States) Up to 31-3-59 (P)	Total population 1951 (in millions)	Agricultural population (in millions)	Net area sown 1951-1952 (thousand acres)
States				
1. Andhra Pradesh . . .	1,06,052	3126	21.04	25,332
2. Assam . . .	84,899	9.04*	6.63	5,081
3. Bihar ..	67,198	38.78	33.31	20,519
4. Bombay ..	1,91,038	48.27	29.88	58,294
5. Kerala ..	15,003	13.55	7.27	4,274
6. Madhya Pradesh ..	1,71,210	26.07	20.33	35,339
7. Madras ..	50,132	29.97	18.81	13,273
8. Mysore ..	74,122	19.40	13.82	23,753

9. Orissa	60,162	14.65	11.61	13,996
10. Punjab	47,084	16.13	10 .60	15,868
11. Rajasthan .	1,32,150	15.97	11.13	23,010
..				
12. Uttar Pradesh . . .	1,13,452	63.22	46.90	40,609,
13. West Bengal ..	33,928	26.30	15.50	12,637
14. Jammu & Kashmir	86,024	4.41†	N..A.	1,532
Total States	12,32,454	357.02	24683	2,93,517
Union Territories				
15. Delhi ..	573	1.74	0.17	224
16. Himachal Pradesh	10,880	1.11	1.03	661
17. Manipur	8,628	0.58	0.48	203
18. Tripura	4,036	0.64	0.48	429
19. Andamans & Nicobar Islands	3,215	0 .03	Neg	10
20. Laccadive, Minicoy and Amindivi Islands	11	0.02	Neg	
Total Union Territories	27,343	4.12	2.16	1,527
Total India	12,59,797	36114	24899	2,95,044

N.A. Not Available.

Neg. Negligible

*Excludes estimates in respect of Part ` B ' Tribal Areas of Assam for which no census was conducted in 1951.

†No census was conducted in the State in 1951, estimated figures have, therefore, been given.

(P) Provisional.

Source : Directorate of Economics and Statistics, Ministry of Food and Agriciulture, New Delhi.

TABLE 3. IRRIGATED AREA (1956-57)

		Area (thousand acres)	Percentage to total
Government canals	..	19,561	35.1
Private canals	.. ..	3,354	6.0
Tanks	.. ..	11,099	20.0
Wells	.. ..	16,226	29.1
Others	.. ..	5,442	9.8
Total net irrigated area	..	55,682	100.0
Rice	.. ..	28,352	44.6
Wheat	.. ..	9,889	15.6
Other Cereals and Pulses	..	12,301	19.4
Sugarcane	.. ..	3,394	5.3
Cotton	.. ..	2,221	3.5
Other Crops	.. ..	7,368	11.6
Total Gross Irrigated Area	..	63,525	100.0

Source : Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi.

TABLE 4. AVERAGE SIZE OF HOLDINGS IN INDIA AS COMPARED TO SOME FOREIGN COUNTRIES

Country	Acres	Year
India	7.5	1961
Denmark	37.7	1951
Holland	26.0	..
Germany (Federal Republic) ..	27.0	..
E. Germany	10.03	1955
France	20.5	..
Belgium	4.5	1950
Britain	66.3	1949
United States of America ..	215.5	1950
Norway	7.5	1949
Sweden	22.1	1944
Yugoslavia	11.7	1950
Japan	2.0	1950
Egypt	2.3	1949
Newzealand	491.0	1949

Source : Congress Agrarian Reforms Committee Report, 1950 and Progress in Land Reforms—1954, U.N. Publication.

TABLE 5. AVERAGE SIZE OF HOLDINGS IN SELECTED STATES

States				Acres	States				Acres
Assam	..	..	..	5.3	Hyderabad	..	..	..	14.1
Bihar	..	..	..	4.1	Madhya Bharat	..	..	..	12.7
Bombay	..	..	..	9.7	Mysore	..	..	..	7.2
Madhya Pradesh	..	..	..	13.9	PEPSU	..	..	..	15.4
Madras	..	..	..	4.5	Rajasthan	..	..	..	16.9
Orissa	..	..	..	5.6	Saurashtra	..	..	..	29.6
Punjab	..	..	..	11.8	Travancore-Cochin	..	..	..	2.4
Uttar Pradesh	..	..	..	5.3	Jammu and Kashmir	..	..	..	3.8
West Bengal	..	..	..	4.7	ALL-INDIA	..	..	..	7.5

Source : *Agricultural Labour Enquiry—Report on Intensive Survey of Agricultural Labour, Volume 1.*

TABLE 6. CROP YEARS

Name of Crop				Duration	
<i>Kharif</i>	..	..	..	1st November	to 31st October
<i>Rabi</i>	..	..	..	1st May	to 30th April
Rice	..	..	..	1st November	to 31st October
Wheat	..	..	..	1st May	to 30th April
Sugarcane	..	..	..	1st November	to 31st October
Cotton	..	..	..	1st September	to 31st August
Jute	..	..	..	1st July	to 30th June
<i>Kharif</i> oilseeds	..	..	..	1st November	to 31st October
<i>Rabi</i> oilseeds	..	..	..	1st April	to 31st March
Tea	..	..	..	1st January	to 31st December
Coffee	..	..	..	1st July	to 30th June
Tobacco	..	..	..	1st March	to 28th February

Note: The beginning of the period denotes the time when generally the crops arrive at the market.

Source : *Indian Crop Calendar issued by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi.*

TABLE 7. SOWING AND HARVESTING PERIODS OF CROPS

Season	Period	Sowing period	Harvesting period	Principal crops
<i>Kharif</i>	May to middle of October.	Generally at the beginning of the South-West Monsoon—May to July.	At the end of the South-West Monsoon, September to October (may continue till November in some cases).	<i>Jowar</i> , maize, rice, castor, sesamum, <i>mung</i> , <i>tur</i> , tobacco, groundnut, jute sugarcane, cotton, <i>urad</i> and <i>bajra</i> .
<i>Zaid kharif</i>	August to January.	August to September.	December to January.	Cotton, rice, <i>jowar</i> , rape and mustard, oilseeds and <i>toria</i> .
<i>Rabi</i>	Middle of Oct. to middle of April.	At the beginning of the cold weather—October to December.	February to April (may continue till May in some cases).	Wheat, barley, oats, potatoes, gram, linseed, mustard and peas.
<i>Zaid rabi</i>	Beginning of Feb. to Beginning of May.	At the beginning of hot weather—February March.	Middle of April to May (may continue up to June in some cases).	Water-melons, <i>toria</i> , <i>jowar</i> , and maize for fodder.

Source : *Indian Crop Calendar issued by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi.*

TABLE 8. SEASONS, DURATION AND SEED RATES OF PRINCIPAL CROPS

Crop	Season	Duration*	Seed rates (lb. per acre)
Rice	Winter	5½—6 months	20—50 (Transplanted)
	Autumn	4 —4½ „	40—80 (Broadcast)
	Summer	2 —3 „	
Wheat	<i>Rabi</i>	5 —5½ „	40—80
<i>Jowar</i>	<i>Kharif</i>	4½—5 „	6—12
	<i>Rabi</i>	4½—5 „	
	<i>Zaid kharif</i>	2½ „	
<i>Bajra</i>	<i>Kharif</i>	4½ „	6—10
Maize	<i>Kharif</i>	4 —4½ „	10—20
<i>Ragi</i>	<i>Kharif</i>	3½ „	10—20
Barley	<i>Rabi</i>	5 —5½ „	40—80
Gram	<i>Rabi</i>	6 „	30—80
Sugarcane	Perennial	10—12 „	
Sesamum	<i>Kharif</i>	*3½—4 „	2—10
	<i>Rabi</i>	5 „	
Groundnut	<i>Kharif</i>	Early	40—80
		4 —4½ „	
		Late „	
		4½—5 „	
Rape and Mustard	<i>Rabi</i>	4 —5 „	4—10
	<i>Zaid rabi</i>	4 „	
Linseed	<i>Rabi</i>	5 —5½ „	10—16
Castor	<i>Kharif</i>	Early-6 „	10—12
		Other-8 „	
Cotton	<i>Kharif</i>	Early	6—20
		6 —7 „	
		Late	
		7 —8 „	
Tobacco	<i>Kharif</i>	7 „	
Jute	<i>Kharif</i>	6 —7 „	6— 8 (Capsularies)

*Denotes the number of months for which the crop is in the land.

Source : Indian Crop Calendar issued by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi.

TABLE 9. SUBSTITUTE CROPS

Area	Crops
Andhra Pradesh ..	(Rice, Ragi, Mesta), (Jowar, Maize, Bajra), Cotton, (Groundnut, Sesamum), (Wheat, Gram), (Chillies, Tobacco, Sugarcane).
Assam ..	(Rice, Jute), (Mung, Gram, Urad, Cotton, Wheat).
Bihar ..	(Ragi, Rice, Jute), (Wheat, Barley, Peas, Gram, Sugarcane).
Bombay ..	(Rice, Ragi, Mesta), (Sugarcane, Wheat, Gram), (Jowar, Bajra, Maize, Cotton).
Madhya Pradesh ..	(Linseed, Wheat, Gram), (Jowar, Bajra, Maize, Cotton).
Madras ..	(Rice, Ragi, Mesta), (Jowar, Maize, Bajra), (Cotton, Groundnut, Sesamum).
Mysore ..	(Rice, Ragi), (Jowar, Sugarcane), (Cotton, Groundnut), (Bajra, Maize).
Orissa ..	(Rice, Ragi, Jute).
Punjab ..	(Wheat, Barley, Gram, Peas), (Jowar, Bajra, Maize, Cotton, Sugarcane).
Rajasthan ..	(Jowar, Bajra, Maize, Pulses), (Wheat, Barley, Gram, Peas).
Uttar Pradesh ..	(Wheat, Barley, Gram, Peas), (Jowar, Bajra, Maize, Sugarcane, Cotton), (Jowar, Bajra, Maize, Mung), (Wheat, Potato, Mung).
West Bengal ..	(Rice, Jute), (Sugarcane, Jute), (Sugarcane, Rice).
Manipur ..	(Wheat, Pea, Mustard); (Maize, Soyabean, Sugarcane).

Source : *Indian Crop Calendar issued by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi.*

TABLE 10. IMPORTANT CROP MIXTURES

State	Crop mixture
Andhra Pradesh	Jowar and Mung; Jowar and Moth. Jowar and Urad; Tur and Cotton; Castor and G. Nut; Cotton and Chillies; Cotton and Korra or Groundnut.
Assam ..	Paddy and Maize; Paddy and Cotton.
Bihar ..	Wheat and Barley, Wheat and Gram; Gram and Barley; Tur and Cotton.
Bombay ..	Rice and Jowar; Cotton and Jowar; Wheat and Linseed; Bajra and Tur. Rice and Cotton; Jowar and Tur; Cotton and Tur; Groundnut and Cotton; Wheat and Gram.
Kerala ..	Tapioca and Beans; Ragi and leguminous crops; Tapioca and Coconut.

TABLE 10. (Concluded)

State	Crop mixture	
Madhya Pradesh	Wheat and Gram; Linseed and Gram; Kondon and Tur; Wheat and Linseed.	Wheat and Linseed; Tur and Cotton; Gram, Cotton and Jowar, Cotton and Gram; Jowar and Urad; Jowar-Mong, Jowar-urad-Moong; Sesamum and Tur; Jowar and Tur.
Madras	.. Cotton and Chillies; Groundnut and Red Gram; Groundnut and Castor; Cotton and Millets; Cumbu and Blackgram; Cholan and Horsegram; Groundnut and Cumbu.	
Mysore	.. Ragi and Jowar; Jowar, Castor and Tur; Tur and Sesamum; Cotton and Minor millets; Tur and Cotton; Jowar and Mung; Jowar and Urad.	
Orissa	.. Horsegram and Mustard; Green-gram and Linseed; Mustard and Linseed; Ragi and Maize.	
Punjab	.. Wheat and Gram; Wheat and Barley; Chari and Moth; Sarson and Wheat; Til and Cotton; Melons and Cotton.	Barley and Gram, Jowar and Guar; Maize and Senji; Toria and Gram; Moth and Cotton; Senji and Cotton.
Rajasthan	.. Wheat and Gram; Gram and Mustard; Barley and Gram; Jowar and Mong.	Wheat and Mustard; Wheat and Barley; Bajra and Moth.
Uttar Pradesh	.. Wheat and Barley; Barley and Gram; Jowar and Arhar; Barley and Peas; Cotton and Arhar; Arhar and Groundnut.	Wheat and Gram; Wheat and Mustard; Maize and Urad; Bajra and Arhar; Gram and Linseed; Wheat, Barley, Gram and Mustard.
West Bengal	.. Wheat and Gram; Paddy and Khisari.	Wheat and Linseed.
Delhi	.. Gram and Wheat; Wheat and Barley; Barley and Gram.	
Himachal Pradesh	Wheat and Barley; Wheat and Gram; Barley and Gram; Wheat and Mustard; Maize and Sesamum; Maize and Pulses.	
Manipur	.. Peas and Mustard, Wheat and Bengalgram or Pea; Rice and Chillies; Cotton and Groundnut (Under shifting cultivation).	

Source : *Indian Crop Calendar issued by the Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi.*

TABLE 11. AVERAGE YIELD (POUNDS PER ACRE) OF IMPORTANT CROPS IN INDIA AS COMPARED TO SELECTED COUNTRIES OF THE WORLD

Crop/Country			Average yield	
Paddy				
India	..	..	1,224	(1.0)
Pakistan	..	..	1,240	(1.0)
Burma	..	..	1,347	(1.1)
China (Mainland)	..	..	2,409	(2.0)
Japan	..	..	3,952	(3.2)
Turkey	..	..	2,444	(2.0)
Egypt	..	..	4,960	(4.1)
U.S.A.	..	..	3,202	(2.6)
U.S.S.R.	..	..	1,918	(1.6)
Thailand	..	..	1,115	(0.9)
Wheat				
India	..	..	701	(1.0)
Pakistan	..	..	687	(1.0)
China (Mainland)	..	..	767	(1.1)
Japan	..	..	1,927	(2.7)
Egypt	..	..	2,067	(2.9)
U.K. ..	..	..	2,846	(4.1)
France	..	..	2,114	(3.0)
Italy ..	..	..	1,534	(2.2)
Belgium	..	..	3,194	(4.6)
U.S.A.	..	..	1,303	(1.9)
Canada	..	..	1,053	(1.5)
Argentina	..	..	1,178	(1.7)
Australia	..	..	669	(0.9)
U.S.S.R.	..	..	830	(1.2)
Maize				
India	..	..	649	(1.0)
Pakistan	..	..	919	(1.4)
Japan	..	..	1,802	(2.8)

TABLE 11. (Continued)

Crop/Country			Average yield	
Indonesia (Java & Madeira)	..	..	767	(1.2)
Egypt	..	..	1,802	(2.8)
France	..	..	2,284	(3.5)
Italy ..	..	..	2,489	(3.8)
Belgium	..	..	4,282	(6.6)
U.S.A.	..	..	2,641	(4.0)
Canada	..	..	3,221	(5.0)
Argentina	..	..	1,749	(2.7)
Australia	..	..	1,517	(2.3)
U.S.S.R.	..	..	955	(1.5)
Sugarcane (In terms of cane)				
India	..	..	32,847	(1.0)
Pakistan	..	..	26,368	(0.8)
Indonesia	..	..	74,849	(2.3)
Hawaii	..	..	1,77,832	(5.4)
Egypt	..	..	80,094	(2.4)
Cuba	..	..	35,033	(1.1)
China (Mainland)	..	..	35,468	(1.1)
U.S.A.	..	..	45,819	(1.4)
Cotton (Ginned)				
India	..	..	93	(1.0)
Pakistan	..	..	187	(2.0)
China (Mainland)	..	..	259	(2.8)
Japan	..	..	116	(1.2)
Turkey	..	..	196	(2.1)
Egypt	..	..	473	(5.1)
U.S.A.	..	..	393	(4.2)
Mexico	..	..	446	(4.8)
U.S.S.R.	..	..	633	(6.8)

TABLE 11. (Concluded)

Crop/Country				Average yield		
Groundnut (Nuts in shell)						
India	..	..	..	..	745	(1.0)
China (Mainland)	..		..	..	999	(1.3)
Japan	..	..	..	..	1,615	(2.2)
Turkey	..	..	..	..	2,070	(2.8)
Egypt	..	..	..	..	1,847	(2.5)
Italy	..	..	..	..	1,766	(2.4)
U.S.A.	..	..	..	..	972	(1.3)

- Notes: A. Figures of yield per acre in foreign countries are not strictly comparable with those for India due to the following reasons:
- (i) The yield per acre in India is estimated on the basis of area sown to crops while in the case of foreign countries, the same is based on area harvested.
 - (ii) In India, more than one crop is raised on the same field; while in other countries generally one crop is raised. As such, the average yield per acre in India in respect of individual crops gets depressed to some extent.
- B. Figures in brackets indicate the relationship of average yield per acre of crops in foreign countries, to those in respect of India, the latter having been represented by unity.

Sources: 1. *India—Latest official estimates—1958-59.*
 2. *Other Countries—Generally based on F.A.O. Yearbook, production—1958.*

TABLE 12. LIVESTOCK POPULATION (IN MILLIONS)

Animals	1945	1951	1956
Milch Cattle—Cows and Buffaloes	27.7	29.2	31.9
Work Cattle and Work Buffaloes	59.3	67.4	70.7
Breeding Bulls—Cattle and Buffaloes	0.8	1.0	0.8
Other Cattle and Other Buffaloes	88.8	101.1	100.1
Sheep and Goats	84.0	86.2	94.7
Fowls and Ducks	58.2	73.5	94.7
Other Livestock—Donkeys, Mules and Camels, etc.	6.9	7.9	8.3

Source : Directorate of Economics and Statistics, Ministry of Food and Agriculture, New Delhi.

TABLE 13. LIVESTOCK PRODUCTS (TENTATIVE ESTIMATES, 1956)

Products				Production	
Milk					
Cow-milk	..	..	..	219	(Million maunds)
Buffalo-milk	..	..	..	294	,,
Goat-milk	..	..	..	15	,,
Total	..	..	..	528	,,
Miscellaneous Products					
Ghee	..	..	..	12	,,
Butter	..	..	..	2	,,
Meat	..	..	..	*461	(Thousand tons)
Eggs	..	..	..	2,085	(Million numbers)
Hides					
Cattle hides	..	..	..	16	(Million numbers)
Buffalo hides	..	..	..	5	,,
Skins					
Goat skins	..	..	..	21	(Million lb.)
Sheep skins	..	..	..	16	,,
Wool	..	..	..	65	,,

Note: Meat includes beef, buffalo flesh, mutton, goat flesh and pork.

*Relates to the year 1949.

Source : Directorate of Marketing and Inspection, Ministry of Food and Agriculture, New Delhi.

TABLE 14. IMPORTS AND EXPORTS OF LIVESTOCK PRODUCTS

Year (April to March)				Imports (crore rupees)	Exports (crore rupees)
1952-53	..	..	..	6.0	17.8
1953-54	..	..	..	10.3	15.3
1954-55	..	..	..	9.6	19.5
1955-56	..	..	..	13.2	18.3

TABLE 15. PRODUCTION OF FISH (THOUSAND TONS)

Year			Marine fish	Marketable surplus of Inland fish	Total
1949	..	..	381	156	537
1950	..	..	571	233	804
1951	..	..	525	215	740
1952	..	..	520	212	732
1953	..	..	572	234	806
1954	..	..	579	236	815
1955	..	..	586	240	826
1956	..	..	707	289	996
1957	..	..	862	352	1,214
1958	..	..	744	304	1,048

Note: The estimates of marketable surplus of inland fish include those of estuarine, riverine and other freshwater sources.

Source : Ministry of Food and Agriculture. [Fisheries (Technical) Section]

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